Cairns in Context:

GIS analysis of visibility at Stelae Ridge, Egypt.

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by

Hannah Pethen

May 2015

Abstract

Cairns in context: GIS analysis of visibility at Stelae Ridge, Egypt.

Hannah Pethen

This thesis describes a new approach tor investigating cairns, stone enclosures, stone alignments and other small archaeological features found in the deserts around the Egyptian Nile valley. Investigation of these features has previously been restricted by their ephemeral nature, damage from modern development and the limited artefactual, epigraphic or archaeological evidence associated with them.

This research focuses on a case study of eight cairns and adjacent courts at the Middle Kingdom carnelian mine of Stelae Ridge in the Gebel el-Asr quarries in southern Egypt. While accepting previous interpretations of the cairn-courts as ritual structures created for the worship of local divinities, this research sought a fuller interpretation of the site in its landscape context and a more nuanced understanding of the structures, their chronological development and the decisions which governed their location and layout. This was achieved through systematic visibility analysis of the eight cairn-courts with geographic information system (GIS) software, which provided new data concerning the patterns of visibility associated with the structures. Interpretation of these patterns in the context of the archaeological and textual evidence from the cairn-courts, practical experience of visibility at the site and evidence from the wider cultural context provided a new and more detailed understanding of the site. Stelae Ridge was chosen because cairns upon it made highly visible landmarks, particularly for people travelling south towards the other sites in the Gebel el-Asr gneiss quarrying region. Initially practical, the Stelae Ridge cairns also developed a ritual function, creating tension between the highly visible cairns and the secluded ritual courts, and suggesting that the cairn-building process became ritualised. By the end of the cairn-building period, in the reign of Amenemhat III, new cairns were constructed in less visible positions, suggesting that the ritual aspects of the cairn-courts had largely subsumed their earlier practical function as landmarks.

This type of GIS research has never been undertaken on Egyptian archaeological sites and previous interpretations of visibility in Egyptian contexts have been limited. The detailed interpretation of the Stelae Ridge cairn-courts achieved here, shows that the technology and approach applied to this research can make a meaningful contribution to the investigation of other similar non-formal structures, and at Egyptian sites in general. It also reveals that GIS visibility analysis can answer relevant archaeological questions, when employed as a tool for data generation and properly contextualised with other evidence from the site.

Acknowledgements

Firstly I would like to thank my PhD supervisor, Ian Shaw, for his help and encouragement, for providing me with the Gebel el-Asr Project survey data, for all his support and advice during various field seasons at Gurob and Stelae Ridge and for his assistance with funding applications. I would also like to thank Matthew Fitzjohn, my second supervisor, for his advice about GIS and more general archaeological aspects of my research. I am grateful to both of them for reading and advising on this and earlier drafts of my thesis. I am also grateful to my examiners Dr Steven Snape and Professor Andrew Bevan for their comments.

I must also thank the Egyptian Ministry of Antiquities, who have given permission for research at Gurob and Gebel el-Asr. I would particularly like to thank the Aswan and Abu Simbel offices and our inspector in 2012, Mr. Tahseen Mohammed Atteya Abd El Motaleb.

I am extremely grateful to the University of Liverpool's PEET travelling prize fund and the Seven Pillars of Wisdom Trust for their generosity in funding the survey at Stelae Ridge in 2012. I would also like to express my gratitude to Molly Houldsworth, whose legacy enabled the purchase of the high resolution Quickbird satellite imagery used in this research.

I would like to thank the large number of people who have contributed ideas, assistance and help over the years. Liz Bloxam's work on Gebel el-Asr and quarries in general has been both inspiring and incredibly useful in this research. I'm particularly grateful to Colleen Manassa, who provided me with photographs and early drafts of her and John Darnell's translations of the Stelae Ridge inscriptions; Anna Hodgkinson, who patiently taught me Quantum GIS and was always ready to help with the Gurob topographic survey; Liz Jones, who taught me so much about surveying and GPS; and Angie Jimenez, with whom I worked at Dra Abu l'Naga. Judith Bunbury and Roland Enmarch have provided general advice, friendship and encouragement, which is much appreciated. I would also like to thank those who were involved in my early research at Gurob, particularly Sarah Doherty, Ian Shaw, Ibrahim Ibrahim and everyone else who helped in the topographic survey work, as well as Jan Picton who kept us all fed and organised.

I could not have done this without my parents, who have always been supportive and have willingly ploughed through various essays and dissertations on a variety of arcane subjects, hunting for typos, errant commas and other minor mistakes. I am also hugely grateful to my husband, Paul Barrett, for his advice on charts and spreadsheets. I could not have achieved this without his love, encouragement and support over the last four years. This PhD is dedicated to him.

Contents

Title page: The two surviving cairns at the north end of Stelae Ridge (Author photograph).

1. Introduction

1.1. Overview

Investigations of the inscriptions, artefacts and archaeological remains of the Egyptian civilisation in the deserts along the Nile valley have been undertaken for over 100 years, but for most of this period researchers have concentrated on archaeological sites with extensive architectural remains or inscribed material. Cairns, stone enclosures, stone alignments and other small ephemeral archaeological features are found in the deserts around the Egyptian Nile valley, often with minimal artefacts or inscriptions. These types of remains are commonly found at mining and quarrying sites or distributed more generally at locations across the desert, but have received limited attention and often defy interpretation with traditional epigraphic, documentary or archaeological approaches. Improved understanding of these remains can reveal how ancient Egyptian individuals and communities interacted with the desert environment away from major cultural loci to achieve practical or ritual purposes in non-formal contexts.

This research constitutes a new approach to the investigation of archaeological features found in the Egyptian deserts, based around a case study of eight cairns and adjacent stone-lined courts at the Middle Kingdom (*c.* 2055–1650 BC) carnelian mine of Stelae Ridge in southern Egypt.[1] The aim is to achieve a more detailed understanding of the site in its landscape context and a more nuanced interpretation of the structures, their chronological development and the decisions which governed their location and layout through systematic visibility analysis, using geographic information system (GIS) software, combined with archaeological and textual evidence and personal experience of visibility at the site. If these methods are successful in revealing new information and improving understanding of the Stelae Ridge cairn-courts, they could be employed elsewhere to assist in the interpretation of other similar archaeological remains, which do not even have the artefactual and textual evidence present at Stelae Ridge and are much more difficult to interpret.

[1] Precise dating of different periods of Egyptian history is disputed. For convenience, the dates used here follow those in Shaw (2000c).

1.2. Non-formal structures at mines and quarries

The cliffs along the edges of the Nile valley and the deserts beyond contain multiple sources of stone, gemstones and precious metals, many of which were exploited by the ancient Egyptians.[2]

Inscriptions are by far the most numerous type of data from quarrying and mining sites, largely because they were of great interest to the earliest Egyptologists, who often paid little attention to other archaeological remains.[3] The various types of inscribed material from multiple periods and various sites have been extensively studied over the past century.[4] New

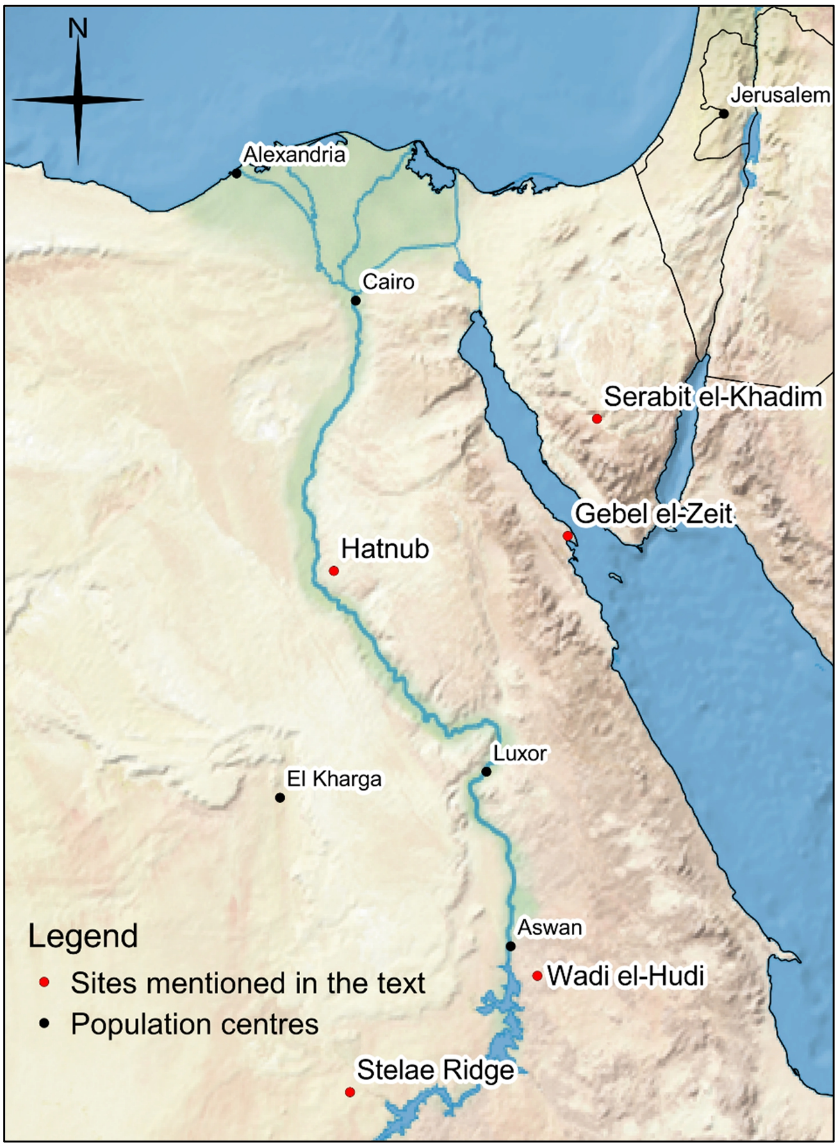


Fig 1.1: Map of Egypt showing the location of mines and quarries mentioned in the text. (Made by the author in QGIS 2.1 using Natural Earth data).

[2] For an overview of mining and quarrying in Egypt see Harrell and Storemyr (2009). For geological descriptions see Klemm and Klemm (2008). For an overview of the many different types of stone exploited by the Egyptians see references in Aston *et al.* (2001) and Harrell (2006). For metals see Ogden (2001).
[3] Petrie (1906) is a notable exception, although it is unfortunate that he did not undertake a more detailed survey or publish more extensive records of the archaeological remains he mentions. Timme (1917) mapped the archaeological remains at Hatnub, but only recorded the larger features.
[4] See for example Abd el-Raziq *et al.* (2002); Anthes (1928); Blackden and Fraser (1892); Blumenthal (1977); Černy *et al.* (1955); Couyat and Montet (1912); Darnell (2013); Darnell and Manassa (2013); Eichler (1994); Espinel (2005); Fakhry (1952); Fraser (1894); Gasse (2012); Iversen (1984); Lloyd (2013); Pirelli (2007); Régen and Soukiassian (2008); Rowe (1939); Sadek (1980); Seyfried (1982); Simpson (1958; 1961); Weill (1904). For other inscriptions not directly associated with mineral extraction see Bard and Fattovich (2013a; 2013b); Darnell *et al.* (2002); Jaritz (1981); Rohl (2000, 14–23); Simpson (1963); and Van Siclen (1982).

studies of mining and quarrying,[5] associated infrastructure,[6] settlements,[7] and the archaeological remains of mining temples[8] have also been undertaken and are revealing much about these aspects of resource procurement.

Investigations into mining and quarrying sites have identified a number of smaller, ephemeral structures including cairns, stone circles, upright stones (orthostats) and stone alignments (Fig 1.1).[9] These features are not large or impressive, they do not represent easily recognisable Egyptian architectural forms and are generally much less formal in design, structure, appearance and contents. As such they bear some resemblance to what Kemp (2006, 113) calls 'preformal' architecture, but 'non-formal' is perhaps better since it avoids any chronological qualification.[10] Most non-formal structures are not associated with inscriptions, have few obvious parallels in Egyptian culture and their function is often uncertain. For these and other reasons, investigation and interpretation of these features has been limited.

1.2.1. Interpretive problems

Historically, investigators only made limited records of the layout and location of non-formal structures, and then only if they were associated with inscribed material. Although Petrie

---

[5] For studies of mines and quarries as extraction sites see Abd el-Raziq *et al.* (2011; 2012); Abdel Maguid (2011); Bloxam *et al.* *(*2014); Castel and Soukiassian (1985b; 1989); Giveon (1974; 1976); Harrell (2002); Harrell and Brown (1994; 1995); Harrell *et al.* (2000); Harrell and Storemyr (2009); Heldal (2009); Heldal *et al.* (2009b); Hikade (2006); Kelany *et al.* (2009); Klemm and Klemm (2008); Klemm *et al.* (2002); Mey *et al.* (1980); Shaw (2000b; 2002; 2003; 2007); Shaw and Bloxam (1999); Shaw *et al.* (1999; 2001; 2010); Shaw and Jameson (1993); Śliwa (1992a); Storemyr *et al.* (2002); various papers in Maniatis (2009); and the discussion and references in Aston *et al.* (2001).

[6]For infrastructure, particularly roads and transport see Bard *et al.* (2013b); Bloxam (2000; 2003a); Bülow-Jacobsen (2013); Eichhorn *et el.* (2005); Shaw (1998; 2006; 2013); Shaw *et al.* (2010); Sidebotham *et al.* (1991); Somaglino and Tallet (2013); Storemyr *et al.* (2013). Earlier studies of roads and other infrastructure include Meredith (1952); Meredith and Treganza (1949); and Murray (1925; 1939).

[7] For settlements see Bloxam (2005); Bonnet (1998); Shaw (1986; 1994; 2000a; 2010); Shaw *et al.* (2010); and Śliwa (1992b).

[8] For examples of temples and shrines see Bommas (2003); Bonnet and Valbelle (1997); Caminos and James (1963); Castel and Soukiassian (1985a); Giveon (1972; 1978); Pethen (2014); Pinch (1993); Rothenberg (1988); Śliwa (2005); Valbelle (1998); Valbelle and Bonnet (1996); and Wimmer (1990).

[9] For cairns, orthostats and stone alignments associated with mines and quarries see Engelbach (1933; 1939); Fakhry (1952, 1–49 and pl. IV); Leclant and Clerc (1985, 394); Petrie (1906, 65–67); Régen and Soukiassian (2008, 8, 42, 49); Shaw (2010, 97–99); and Storemyr *et al.* (2013, 415–418). Features described by Weigall (1909, 182) at Gebel Tingar are now known to have been located in a silicified sandstone quarry (Harrell and Storemyr 2009; Heldal 2009).

[10] Kemp's chronological model of the development of the typical Egyptian temple has been widely challenged and debated (Bussmann 2010; O'Connor 1992; Seidlmayer 1996: 115–119). Given the juxtaposition of 'formal' Middle Kingdom texts with 'preformal' structures at sites like Serabit el-Khadim, Stelae Ridge and Wadi el-Hudi, Kemp's overtly chronological terminology is not particularly appropriate (Pethen 2006, 13–15). Darnell and Manassa (2013, 90) use 'informal' for similar reasons.

(1906, 65-67) unusually took time to record the presence of upright stones and stone circles at Serabit el-Khadim, he did not record the layout of the features and his focus upon the enclosure with inscribed material is typical. Similarly, Weigall (1907, 182; 1909, 163–4) mentioned cairns and a possible rough shrine in passing, but was unwilling or unable to make a detailed record. Engelbach (1939, pl. LIV) recorded the layout of the cairns and courts at Stelae Ridge, but only the eight central structures which had yielded stelae, and then only as a sketch. The published records of the archaeological context of the original investigations at Wadi el-Hudi are similarly limited to sketch plans and rough descriptions of each location (Fakhry 1952).

Over the intervening century their insignificant appearance and, sometimes, peripheral location has resulted in the destruction of many cairns, stone circles and orthostats, making it impossible for more recent expeditions to record and map them properly. Typical of this is the extensive damage to the eight cairns on Stelae Ridge, which occurred as a result of nearby construction works from 1980 onwards.[11] A more recent example was noted at Hatnub in 2011–2012. Several of the cairns recorded in the 1980s have been destroyed since then, particularly cairn C7 on the highest point near Quarry P.[12]

Where cairns and stone circles do survive, they may not be included in survey and excavation and published references may be limited. When a site includes extraction and processing areas, settlements, roads and even a temple or a shrine, peripheral cairns, stone circles and alignments are likely to be low on the list of priorities for investigators with limited time and finances.[13] Typical of this is the recent publication of the Middle Kingdom temple of Hathor at Serabit el-Khadim. Although the authors mention secondary cult places (Valbelle and Bonnet 1996, 66–67) and discuss the stone circles identified by Petrie, they only provide a single small map of the stone circles along the approach to the temple and consider the structures primarily from the perspective of the inscribed material found within them (Valbelle and Bonnet 1996, 70–72; plan 1). There is no indication of the distribution and location of the secondary cult places, and the orthostats and stone alignments are barely mentioned at all. The publication of material from Gebel el-Zeit exhibits similar focus upon the mines (Castel and Soukiassian 1989) and inscribed material (Régen and Soukiassian 2008), but pays so little attention to the peripheral cairns and stone circles that it is unclear from the published

[11] The damage to the structures on Stelae Ridge was recorded by the Gebel el-Asr Project (Shaw *et al.* 2010, 302–303; Storemyr 2009, 114). It is discussed in this thesis in Chapter 3, section 3.1 and 3.5–3.7 and documented in the satellite imagery presented in Chapter 4 section 4.5.

[12] See Shaw (2010, 97–99) for a description and images of this cairn when still standing.

[13] Although Shaw's (2010, 97–107) chapter on such structures at Hatnub and coverage of similar structures on the West Bank at Aswan (Storemyr *et al.* 2013b) are notable exceptions.

record whether the roughly carved falcon figures in one of these stone circles were three-dimensional or inscribed on a stela (Pethen 2014, 155).

Even when cairns, stone circles, orthostats and stone alignments have been recorded, there are a number of difficulties associated with interpreting them. In the most extreme cases, such features exist without inscribed material, artefacts or stratigraphy, which might provide an indication as to date or purpose. This is of some importance, given that cairn construction is recorded as recently as the early 20th century,[14] and the construction of orthostats and stone alignments is known to extend back into the predynastic period.[15]

In addition to problems with dating, a lack of contextual information has also led interpretive cul-de-sacs. At Serabit el-Khadim Petrie (1906, 65–70) interpreted the orthostats as evidence of near eastern religious practices and the stone circles as structures for incubation of dreams. Both these interpretations have since been shown to be false (Shaw 2010, 101; Valbelle and Bonnet 1996, 69–71).

Elsewhere the lack of contextual evidence simply limits what can be inferred about the structures. At Hatnub interpretation of the cairns, shrines and orthostats was limited by the absence of any artefacts, inscriptions or stratigraphy with which to contextualise them. Cairn C7 was tentatively dated to the Old Kingdom (*c.* 2686–2125 BC) because of Old Kingdom parallels for the petroglyphs located at its base and Old Kingdom activity in nearby Quarry P (Shaw 2010, 97–99). Other cairns, orthostats and shrines defied precise dating. The Hatnub ‘shrines’ comprised small cairns or domed structures, often containing a small interior space, with an approach path worn clear of stones. As to purpose, the most that could be said about the shrines was that they were probably ritual structures because they did not exhibit any evidence of burning, which might have indicated they were ovens and they were too small to have served any other practical purpose. The petroglyphs associated with cairn C7 and an apparent relationship between some cairns and some shrines, implied that at least some of the cairns also had a ritual function (Shaw 2010, 101–105), but little more could be deduced from the available evidence.

Storemyr *et al.* (2013b, 415–418) had similar problems with non-formal structures in the quarries on the West Bank at Aswan. They noted that some structures appeared to be associated with good visibility, some with roads and others with typical ritual structures of

[14] See ethnographic records of cairn construction by Egyptian Bedouin and other travellers in Murray (1935, 194–195) and Forbes (1921, 268 and 289).
[15] See Wendorf *et al.* (1996; 2001, 489–502) for the use of stone alignments in a Neolithic complex at Nabta Playa.

various periods, but could deduce no more about them from the very limited archaeological evidence.

Where contextual information survived and has been recorded, the combination of limited archaeological recording and recent damage often makes interpretation difficult. Engelbach's reports tantalisingly suggest that the structures on Stelae Ridge were once associated with artefacts that were not recorded by him and which have since disappeared. In addition to the stelae, offering tables and falcon figures he removed from the site, Engelbach also described 'other antiquities (Engelbach 1933, 68)'. In his inventory of the artefacts removed from Stelae Ridge, he includes four which were 'left in place' and excludes several which he says 'are from outlying cairns, which we have not been able to include in the maps (Engelbach 1939, 387)'. The absence of any record of the artefacts excluded from the list or left in place means research into the site lacks possibly useful pieces of contextual evidence. Two stone pyramidia were found on Stelae Ridge by the Gebel el-Asr Project together with an additional stela 30m to the southwest (Shaw *et al.* 2010, 302), but other significant pieces of evidence may have been lost during the damage to the site since the excavations by Engelbach.

Together the cairns, stone circles, orthostats and stone alignments form a group of smaller, non-formal structures that are known to exist or have existed at multiple mining and quarrying sites. It is likely that similar features were present in and around other mines and quarries and at other locations,[16] but many of these have not survived to be identified and recorded. Interpretation of the surviving corpus of such features is difficult due to their limited numbers, damage and destruction over the past century, the limitations of early archaeological records and the minimal contextual evidence surviving at the few well preserved sites.

1.2.2. Previous interpretations

Various interpretations have been advanced regarding the function of cairns, stone circles, orthostats and stone alignments. Apart from the purely practical interpretation of some cairns as landmarks, most interpretations of non-formal structures see them as ritual constructions.

---

[16] For similar structures, particularly cairns, in other locations see Bard *et al.* (2013, 536); Darnell and Darnell (1993, 48–55; 1994, 40–43); Jaritz (1981, 246 and pl. 39–40); Keating (1975, 127–128); Mills (1968, 206); Rose (1996); Simpson (1963, 36–44); Trigger (1996, 804 and 806); Weigall (1907, 182; 1909, 163-4); and Winlock (1936, 44 and pl. 33).

A general ‘votive’ interpretation has been advanced for various groups of cairns, including the Stelae Ridge cairns.[17] Engelbach (1939, 388) invoked a similar concept when he suggested a group of cairns on ’20 cairn hill’ were erected as ‘propitiatory offerings’ . The same type of idea occurred to Weigall (1907, 163–4) when he described cairns in the eastern desert as ‘altars’ and other examples at Aswan’s Gebel Tingar as the ‘prayers of those who asked for a prosperous journey (Weigall 1909, 182)’. Interpretations and descriptions of artefacts and structures as ‘votive’ is relatively common in Egyptian archaeology. Although there can be problems with uncritical use of the term ‘votive’,[18] it is usually used in the general sense of a ‘gift to a deity (Pinch 1993, 1)’ rather than with a more specific meaning of *ex voto*. The general archaeological usage of the term is well expressed in Osbourne (2004, 1) as ‘an act directed at communication with or concerning supernatural powers’. This definition fits with the concept behind Engelbach’s ‘propitiatory offerings’ and Weigall’s more picturesque description. It is also a concept consistent with Egyptian religion and ritual, which involved offering rituals of gifts and sustenance for the gods and the dead, on national and personal levels.[19]

However, while ‘votive’ or ‘propitiatory’ structures are consistent with Egyptian concepts, assigning such a term to the non-formal structures reveals very little about how they were integrated into ancient cultural concepts or involved in social interaction between humans and the supernatural. Given the often limited contextual evidence, it is also difficult to escape the impression that the use of ‘votive’ in such contexts is consistent with the archaeological cliché that things are classified as ‘ritual’ because there is no evidence for any suitable alternative function.[20]

‘Ritual’ as an interpretation has previously been both underrepresented and gratuitously but meaninglessly overused.[21] It is as vague and contested as ‘votive’, if not more so, but most agree that it is multi-faceted with many attributes. There are different types of ritual and

---

[17] For the identification of the cairns as ‘votive’ see Darnell and Manassa (2013). They also suggest that similar groups at Gebel Antef and on the Ain Amur road may have had the same function.
[18] See particularly Renfrew (1985, 1–22), who points out that it is difficult to develop a rational method of identifying votive or ritual sites. Insoll (2004, 10–12) notes that ‘ritual’ is often used to classify things for which no functional explanation can be discerned and those which are simply not understood. Therefore it can be both simplistic and confusing.
[19] For offering rituals in temple religion and ritual see Baines (1991) and the summary and references in Teeter (2011, 39–51). For interactions with the dead see Harrington (2013, chapter 2) and Teeter (2011, 128–132). For personal and private religion see the summaries in Stevens (2011, 728–737); Teeter (2011, 76–102) and Sadek (1988). See also Stevens (2006, 17–21) for a discussion of private and public religion in reference to a specific site, Pinch (1993) for the uses of votive artefacts and Spence (2007) for possible archaeological evidence of domestic offering rituals.
[20] This point has been made by several archaeologists including Brück (1999) and Hodder (1982, 164; 1992, 222–223) and is discussed further in Insoll (2004, 11).
[21] See the discussion in Insoll (2004, 10–12).

various archaeological and anthropological approaches.[22] There is also a distinction between 'ritual' and 'religion', although ritual is often held to be a central element of religion (Verhoeven 2011, 124–6).[23] In terms of Egyptian religion and ritual Stevens (2006, 21–22) makes a useful distinction in her division of 'religion' into action and conduct. Religious conduct involves the supernatural but does not require physical or conscious effort on the part of the human. Religious action requires physical and conscious effort on the part of the human participant and thus would include religious rituals, according to almost any definition of ritual. Egyptian religion displayed both religious conduct and religious action, but religious interpretations offered for the non-formal structures at the mining sites explicitly or implicitly fall within the category of religious action and are 'ritual' in nature.

Within the many dimensions of 'ritual' as defined and studied by archaeologists, some are particularly relevant to the consideration of the non-formal structures at Middle Kingdom mines and quarries. They raise a number of questions and concerns with previous 'ritual' interpretations of these structures and suggest that further investigation is required to explore their meaning fully.

Modern research into ritual has long emphasised the importance of correctly identifying ritual structures. This is particularly important where the interpretation of a site or context as 'ritual' is questionable. While there is general agreement that explicit identification of ritual is necessary, methods vary from the search for specific indicators of 'cult', to framing and contextualisation. [24]

Ethnocentrism and the division between the sacred and the profane in modern society, have caused problems in the identification of ritual structures. Following western rationalist thought, objects or structures without any apparent rational or practical purpose have been classified as 'ritual' while those with a possible practical purpose are not, but these divisions may not be meaningful in ancient societies (Brück 1999; Verhoeven 2011, 124).

---

[22] See the excellent summary and references in Verhoeven (2011) concerning 'ritual' in archaeological thought and practice to date. For examples of varying approaches and contexts see the many papers in Barrowclough and Malone (2007); Bertemes *et al.* (2001); D'Agata *et al.* (2009); Kyriakidis (2007) and Moser and Feldman (2014). See also Bell (1997a, 138–69) for the basic attributes of ritual.

[23] Insoll (2004, 2–3; 10–12) notes and criticises two apparently opposing tendencies either to separate religion and ritual, or equate the one with the other.

[24] Renfrew (1985; 1994b) proposed that cultic contexts could be identified on the basis of a number of specific features, but this has since been criticised as 'checklist approach (Hodder 1992, 152; Insoll 2004, 96–97)'. Framing (Verhoeven 2011, 126–7) involves the search for evidence of separation for ritual purposes, which can then be contextualised to expand the investigation to other similar contexts elsewhere.

Engelbach's (1933, 68) assumption that the Stelae Ridge cairns 'obviously fulfilled the purpose of landmarks' is a good example of how the separation between the sacred and profane affected earlier interpretations. He is probably right to some extent, as other cairns clearly did function as landmarks on routes across the desert.[25] However, one or two cairns would presumably have served as well to mark Stelae Ridge as all eight. His explanation is therefore rather superficial and does not address questions like why Stelae Ridge was chosen, which cairns were landmarks and why so many were constructed in one place. It also fails to address whether such structures were purely practical or whether they could have a dual function. At Stelae Ridge, Serabit el-Khadim and Gebel el-Zeit, the artefacts and inscriptions revealed that there was a ritual component to the non-formal structures,[26] even if they also served a practical purpose. Simplistic practical or ritual dichotomies are therefore insufficient. The surviving artefacts and inscriptions cannot answer all pertinent questions about the position and layout of the structures, whether they had any practical aspects to them, how these related to their ritual functions and how far they might constitute evidence of ritualisation.[27]

Where remains have been identified as ritual features because there is no evidence of a practical function, it would be helpful to have positive evidence for that interpretation. Petrie, Engelbach and Weigall simply assumed that the features they observed had a ritual purpose because they could conceive of no practical purpose for them.[28] Where possible alternative purposes are explicitly considered, the very limited evidence means interpretations are equally limited.[29] Acknowledging that the lack of evidence makes interpretation difficult, at

---

[25] Cairns that can confidently be identified as landmarks include those located between Stelae Ridge and the Nile (Engelbach 1939, 388; Shaw 2006), cairns on the Abu Ballas trail (Förster 2007; Förster 2013; Riemer 2013), cairns on routes within Kharga oasis (Rossi and Ikram 2013, 270); cairns along the road between Hatnub and the Nile valley (Shaw 2013) and other regularly spaced cairns located along routes between ancient sites.

[26] For interpretation of the Stelae Ridge cairn-courts as ritual structures see Bloxam (2006); Darnell and Manassa (2013) and Pethen (2006; 2014). For the clear ritual purpose of the temple and enclosures at Serabit el-Khadim see (Valbelle and Bonnet 1996). For the shrine and enclosures at Gebel el-Zeit see Castel and Soukiassian (1985a; 1985b; 1989, 51) and Régen and Soukiassian (2008).

[27] Ritualisation, the process by which behavioural forms are modified and combined to form a ritual is summarised in Verhoeven (2011, 123) following Humphrey and Laidlaw (1994) and Bell (1993). Bradley (2005) is the best example of the use of the concept to interpret archaeological evidence. Although she does not make use of the concept of ritualisation, Meskell (2004) has recently attempted a more holistic analysis of Egyptian material, which could allow for both practical and ritual interpretations.

[28] The Serabit el-Khadim orthostats and stone circles without stelae (Petrie 1906, 67–69); groups of cairns without stelae at Stelae Ridge (Engelbach 1933, 69; 1939, 388); and 'altars' in the eastern desert (Weigall 1907, 163–164) were all identified as some form of ritual structure without any evidence or discussion.

[29] The structures at Hatnub are typical of this. Cairn C7 and the orthostats were identified as ritual structures because of parallels for the petroglyphs at the cairn and similarities between the orthostats

sites like Hatnub it would be helpful to have positive evidence in favour of a posited ritual usage.

Egyptologists often suffer from a second, more culturally specific form of ethnocentrism, an ethnocentrism based in the elite Egyptian attitudes to life, society, religion and ritual. The 'self-evident (Kemp 2006, 113)' religious or ritual context of many Egyptian structures combined with the dominance of elite literary and cultural material has traditionally resulted in the impression that the religious concepts and ritual practice of a relatively small elite group are representative of those of the entire society.[30] Recent studies suggest that this assumption is no longer as prevalent,[31] but it certainly influenced earlier researchers like Petrie, Engelbach and Weigall. Petrie's (1906, 65–67) erroneous interpretation of the Serabit el-Khadim orthostats as Canaanite structures was influenced by his assumption that they were 'un-Egyptian'. Similarly, the rather superficial interpretations of cairns as 'votive', 'propitiatory' and 'altars' by Engelbach and Weigall probably stem from the failure of these structures to conform to those archaeologists' pre-conceived typologies of Egyptian religious structures, typologies that are based on the 'self-evident' temples, tombs, shrines and homogeneous religious inscriptions of the Nile valley elite.

Engelbach's (1933, 69) interpretation of the Stelae Ridge cairns and Borchardt's (1897) interpretation of the Hathor cave at Serabit el-Khadim as funerary monuments is probably also due to a desire to conform to a known Egyptological paradigm, in this case the tomb. Borchardt's argument that the Hathor cave at Serabit el-Khadim was a tomb has been comprehensively refuted by Valbelle and Bonnet (1996, 85). Engelbach's claims about Stelae Ridge were based on a human radius and ulna he found in one of the courts, which he suggested came from one of the four circular depressions visible on the ridge. He assumed these depressions had previously contained inhumations covered by additional cairns, which were later demolished by the Romans.[32] However, this explanation does not seem sufficient. Given that there were four depressions on the ridge, if they all contained

---

and the stone alignments at Serabit el-Khadim and Nabta Playa. The shrines were identified as ritual structures because no practical purpose was attested from the limited evidence (Shaw 2010, 97–105).

[30] This problem is discussed by Grajetzski (2010, 181–184) in relation to class in general; by Stevens (2011) in relation to ritual and religion; and is considered from an archaeological perspective by Bussmann (2010; 2011); and Kemp (2006, 111–113). Baines (1987, 1991) also discusses it, although his reliance on textual sources means the examples of 'private religion' and piety he gives are still associated with the small literate section of society.

[31] See for example Bloxam (2006); Bomann (1991); Bussmann (2010; 2011); Meskell (2002, 1–16); Richards (2005, chapter 2); Snape and Wilson (2007, 33–68); Spence (2007); and Stevens (2003; 2006, 17–21).

[32] Evidence of Roman presence comprised two shards of Roman pottery found by Engelbach (1933, 68) and the Gebel el-Asr Project (Shaw 2000a, 30).

burials it is surprising that neither Engelbach nor the Gebel el-Asr Project found more bones. Furthermore, if other cairns had covered burials, some evidence of the inhumations should have been visible to the Gebel el-Asr Project, since by the time they worked at the site many more of the cairns had been demolished.[33] Engelbach pulled down one of 13 cairns on another hill to the south of Stelae Ridge, but he found no burial. Elsewhere in Nubia there were no burials beneath cairns at Qasr Ibrim (Rose 1996, 98–99) or Semna (Mills 1968, 204). Thus while it is possible that in some cases cairns could cover burials, it is certainly not true of all. Each site needs to be considered individually. Attempting to conform every interpretation to a ‘top-down’, elite-dominated view mediated by the artefacts, structures and inscriptions of traditional Egyptology fails to satisfactorily explain all sites, or even all aspects of one site.

Bloxam’s (2006) cross-cultural interpretation of the ritual structures, ‘Hathoric’ imagery and inscriptions at Serabit el-Khadim, Gebel el-Zeit, Stelae Ridge and elsewhere was an explicit attempt to interpret the evidence without relying upon ‘top-down’ approaches mediated by elite Egyptian material. She sees the Egyptian artefacts and inscriptions present at these sites as prestige items given to local groups in return for obtaining and even transporting the desired gemstones to the Nile valley.

Unfortunately, there are some flaws with this argument. The suggestion that the Egyptian objects were gifts given to and set up by local groups who extracted and provided the minerals, relies upon the same underlying assumption made by Engelbach and Petrie, that their context is inherently ‘un-Egyptian’ and must be the result of some ‘other’ cultural group. Aside from the circularity of that argument, it cannot be substantiated when the layout of the structures and arrangement of the artefacts are considered in more detail. Investigations of the layout and arrangement of the temple at Serabit el-Khadim and the Stelae Ridge cairns found considerable Egyptian archaeological and textual parallels,[34] and revealed that the layout, organisation and positioning of the inscriptions and artefacts conformed to Egyptian practice. The correct layout of different inscribed artefacts in relation to each other also implies that it was undertaken by people who could read the content. If the objects were

[33] For the damage to the site see references in footnote 11.

[34] For Egyptian textual and archaeological parallels see Darnell and Manassa (2013); and Pethen (2006; 2014). Other Middle Kingdom mining sites with similar evidence include Serabit el-Khadim (Černy *et al.* 1955; Petrie 1906, 65–69; Valbelle and Bonnet 1996); Gebel el-Zeit (Castel and Soukiassian 1985a; Régen and Soukiassian 2008); Wadi el-Hudi (Fakhry 1952; Sadek 1980; Shaw 1998) and some texts in the Wadi Hammamat (Lloyd 2013). Similar structures, housing stelae dating to the 12th Dynasty were also found at the port of Mersa Gawasis on the Red Sea (Bard *et al.* 2013). Similar sites within the Nile valley include the ‘Terrace of the Great God at Abydos’ (O’Connor 1985; Richards 2005, 38–45; Simpson 1974; 1980) and the shrine of Heqaib at Elephantine (Franke 1994; Habachi *et al.* 1985).

gifts, either the Egyptians had considerable input into how they would be deployed or the local groups were sufficiently comfortable and invested in Egyptian culture to set them up in an appropriately Egyptian style.

This is not to deny that local groups could have been present at the sites, interacted with the Egyptians and exploited the resources for their own purposes. It merely argues that the Egyptian artefacts and inscriptions were set up by Egyptians, that is by people who could read Egyptian scripts and arranged the sites in accordance with patterns reminiscent of those from other mines and quarries and sites in the Nile valley.

Thus while overreliance on interpretation based upon traditional elite Egyptian models risks overly ‘top-down’ conclusions, entirely excluding such evidence can also cause problems. It may obscure significant elements of the overall pattern as well as the differences between individual sites.[35] To avoid this, site-based interpretations are required and multiple sources of evidence should be sought. Unfortunately various problems and circumstances have resulted in relatively little evidence being available for traditional archaeological and Egyptological analyses. The amount of textual, artefactual and contextual evidence varies, but in the most extreme cases there is almost nothing.

1.3. Investigation with visibility analysis

Cairns, stone circles, shrines and standing stones at Middle Kingdom mining sites have received limited study in comparison to the other features of those sites, due to a lack of evidence resulting from poor early records and more recent destruction. Where they have been studied, interpretations have been limited by the lack of evidence. Differences between these non-formal structures and better known Egyptian material culture, the preconceptions of some early archaeologists and the difficulties of interpreting such remains using traditional archaeological and Egyptological methods have also contributed.

To resolve the problems associated with interpreting these non-formal structures, new methods of interpretation, both theoretical and methodological, are needed. These methods need to take account of the limited contextual information present at the sites, consider

[35] There are a number of differences between the sites considered by Bloxam (2006), which may be significant to any interpretation. Serabit el-Khadim, for example, is a much more extensive site with a much larger number of artefacts and inscriptions and a highly developed mythology associated with mineral extraction (Valbelle and Bonnet 1996, 123). Gebel el-Zeit by contrast is much smaller and more limited in scope, and surviving inscriptions suggest that rituals undertaken there had a slightly different focus from those at Serabit el-Khadim or Stelae Ridge (Régen and Soukiassian 2008).

current thinking in archaeological theory and method and also take account of information concerning Egyptian culture where this is available and relevant.

There is one element of contextual information that is available at every site, the landscape in which these features are located. Modern landscape archaeology includes a wide variety of theoretical constructs and interpretive approaches for landscapes and cultures of various types across the world.[36] In this case visibility analysis has been chosen, because it permits investigation of potential visual relationships between structures and their surroundings. This allows specific questions to be considered, which can relate directly to theories about the archaeological remains. It is also appropriate to the environment of the sites and their cultural context. As these sites are located in the desert with relatively monochrome colouring and minimal vegetation, visibility is generally good and well-placed structures can stand out from a distance. Equally, evidence from ancient Egyptian culture suggests that the visible form of things was important and that visibility could be significant in the location and layout of Egyptian sites.

1.3.1. Visibility and Egyptian archaeology

The visual nature of the hieroglyphic script and its highly symbolic character reflect a relationship between visibility, image and meaning. Egyptian scripts blurred the boundary between texts and images,[37] and the presence of natural or naturally derived symbols within both text and religious image suggests that the Egyptians experienced significance in the visual appearance of things, including the landscape.[38] Examples of this include the resemblance of the Amarna landscape to the Egyptian hieroglyph for the horizon, which probably influenced the choice of the site for the city named ‘Horizon of the Aten’ and the location of the royal tomb (Aldred 1976). The topography of the west bank at Luxor and the position of the Giza Sphinx between the pyramids of Khafre and Khufu have both been

---

[36] See for example the many approaches, examples and references in David and Thomas (2008).
[37] The relationship between text and image in Egyptian culture is summarised in Hornung (1992, 17–36) and discussed in more detail with relevant references in Baines (2007, 281–297). As text and image were inscribed together in temples and tombs they created a language of symbols that were reiterated and reinterpreted as religious concepts developed. This process can be followed for solar religion (Assmann 1995) and the mortuary deity Osiris (Rundle-Clark 1959) amongst others.
[38] Richards (1999) discusses this in general and in the context of the sites of Abydos and Amarna.

associated with the hieroglyph for horizon.[39] Elsewhere the suggestive shape of pinnacles of rock at Deir el-Bahri and Gebel Barkal has been linked with the worship of local divinities.[40]

At the opposite end of the scale, the layout and structure of typical Egyptian temples is related to a symbolic model of the universe.[41] Pyramids represent the primeval mound, as well as having associations with the sacred *ben-ben* stone of the sun-temple at Heliopolis and the sun's rays.[42] The choice of the Valley of the Kings as a royal burial place has been related to the pyramidal appearance of the mountain 'El-Qurn' above it.[43] This brings the argument full circle as a physical location is chosen for its resemblance to a powerful and sacred structure, whose form was influenced by mythical landscape features, which were in turn based upon metaphors derived from the real landscape.

The preoccupation of these studies with tombs and temples and their dependence upon relationships between physical structures and specific hieroglyphs or symbols is consistent with the sites and texts that have informed much Egyptian archaeology. There are very few studies which consider the wider visibility of a site within its landscape and the effect of the visual experience of that landscape upon the location, layout and construction of the archaeological features.

---

[39]For the significance of the shape of El-Qurn at Luxor see Reeves and Wilkinson (1996, 17). The Great Sphinx has been interpreted by Lehner (1991) as representing the sun rising or setting, with the two larger pyramids of Giza representing the two hills on either side of it in the hieroglyph for 'horizon'. Goedicke (1995, 45) claims that on the evening of the summer solstice the sun sets between the pyramids of Khufu and Khafre.

[40] Both sites are discussed in detail in an article by Donohue (1992).

[41] This is well summarised in Shafer (1997, 4–6) and Wilkinson (1994, 27–29) following ideas present in Hornung (1992, 115–29), Reymond (1969) and Saleh (1969).

[42] The relationship between pyramid, primeval mound, *ben-ben* stone and sunlight are summarised with additional references in Lehner (1997, 34–35) and discussed in more detail in Edwards (1993, 279–283). Quirke (2001, 115–134) gives a more detailed review of possible associations of the pyramid.

[43] See Reeves and Wilkinson (1996, 17).

Of those studies which do consider visibility,[44] almost none make use of geographic information system (GIS) software or phenomenological approaches.[45] Instead most studies make brief reference to visibility, or inter-visibility, and provide photographs, maps or google earth imagery to support their conclusions. While many of these suggestions are appealing or intriguing, in most cases a more detailed analysis would be beneficial to supply additional evidence in support of the conclusions.[46] Such an analysis would need to address issues like the differences between the modern and ancient landscape, the question of visual acuity and atmospheric extinction and even whether ancient viewers would have been of similar stature to modern archaeologists. These practical matters are rarely explicitly considered in discussions of visibility in Egyptian archaeology, much less more theoretical concerns relating to the experiences of different genders or cultures.[47]

Perhaps more significantly still, systematic analysis of sites of interest might reveal unexpected aspects of visibility that are not immediately apparent to subjective observation. These could include visual relationships not immediately apparent or areas excluded from visibility. While the possibility that visibility may be deliberately excluded or limited has been

---

[44] It has been suggested that the First Intermediate Period (*c.* 2160–2055 BC) and Old and Middle Kingdom tombs in Middle Egypt are located where the high and impressive cliffs on the east bank of the Nile provide a suitable 'visual framework' that stands in for the usual mastaba or similar tomb superstructure (Jeffreys 2010, 109–110). At Abydos, the layout of the Predynastic and Early Dynastic (*c.* 3200–2686 BC) funerary sites in relation to the wadi system has been interpreted as evidence that sightlines from the settlement to significant landscape features were planned into the construction of these sites. The Middle Kingdom and New Kingdom (*c.* 1550–1069 BC) structures at Abydos are located against an escarpment which appeared pyramid-shaped when viewed from the tomb causeways to the east. (Richards 1999; Wegner 2007). Jeffreys (1998) suggests that the locations of the Memphite pyramids were associated with their visibility from the cult centre at Heliopolis and the settlement of Memphis. Love (2004, 120–122) comments on the visibility of the Memphite pyramids from Heliopolis and considers the dominance of the Memphite pyramids and their inter-visibility, but offers no systematic assessment and does not take into account practical issues like atmospheric extinction or visual acuity.

[45] Notable exceptions include research into the visibility of New Kingdom tombs at Dra Abu el-Naga, which makes use of GIS to reconstruct the landscape and assess visibility (Jimenez Higueras 2012); and phenomenologically influenced research into ritual structures and locations in the south-eastern desert (Garnett 2013). Some authors accept and refer to phenomenologically influenced ideas about the role of Egyptian inscriptions, rock art and structures in 'socialising the landscape' or 'place-making' (Bloxam 2006; Darnell 2009; Riemer and Förster 2013, 39–42), but they are not undertaking phenomenological research. Various projects, including Corrie (2011); Heldal *et al.* (2009a) and Ignacio *et al.* (2012), make use of GIS but not in the context of visibility. Meskell (2002; 2004) makes explicit use of phenomenology, but in terms of an embodied approach to daily life and artefacts, rather than with reference to landscape and visibility.

[46] Jeffreys (2010, 114) acknowledges the need for more detailed analysis of a model of the entire Memphite pyramid field to support his suggestion that the different sizes of the pyramids were intended to ensure they appeared the same size when viewed from the settlement.

[47] The problem of assessing how individuals of different statures, genders or cultures would experience the same landscape has posed problems for both GIS-based and phenomenological investigations of visibility. For criticisms of GIS from this perspective see Chadwick (2004) and Tilley (2004b). For similar criticisms of phenomenology see Brück (1998) and Meskell (1996).

noted in some cases (Jeffreys 2010, 115), it is possible that new, highly consistent or unexpected patterns of exclusion may be observed through more detailed investigation.

1.3.2. Visibility and archaeology: GIS and phenomenology

The last twenty years has seen increasing investigation of visibility and inter-visibility in archaeology through the, often conflicting,[48] approaches derived from phenomenology and GIS.[49] Phenomenological approaches have been criticised for their reliance upon modern landscapes, lack of explicit and rigorous methods, subjectivity and inability to consider the breadth of human experience.[50] Opposition to the use of GIS to investigate visibility concentrates on concerns that GIS is inherently dehumanising, technologically deterministic, associated with a false scientific objectivity and an incipient environmental determinism.[51]

These criticisms and other practical concerns have been absorbed by many archaeologists using GIS[52] and efforts have been made to resolve these issues through increasing engagement with archaeological theory and methodological change.[53] This process is still continuing. The December 2012 issue of the *Journal of Archaeological Method and Theory* followed the theme 'In Search of the Middle Ground: Quantitative Spatial Techniques and

---

[48] The conflict between experiential qualitative investigations of visibility based in phenomenology and the use of GIS in visibility analysis was discussed in more detail in Exon *et al.* (2000, chapter 2) and Pethen (2012).

[49] Brück (2005) provides a succinct summary of phenomenology with particular regard to landscape archaeology. The approaches of Tilley (2008b) and Thomas (2008) are summarised in David and Thomas (2008), together with other approaches to landscape archaeology. Phenomenological research into landscapes generally involve written and pictorial records of the researchers' personal experience, sometimes matched with descriptions of the experience of others and other relevant contextual information (Bender *et al.* 1997; 2007; Cummings 2002; Cummings and Whittle 2003; 2004; Thomas 1995; 2001; Tilley 1994; 2004a; 2004b; 2008a;).
The GIS-based approaches to investigating visibility, including problems and theoretical aspects are summarised in Chapman (2006, 135–138); Conolly and Lake (2006, 225–233); and Wheatley and Gillings (2002, 201–216). Typically GIS-based visibility analysis is used for answering simple questions of what is visible from where (Gaffney and Stancic 1991, van Leusen 1993); demonstrating new methods and techniques for improving GIS-based visibility analysis (Fisher 1991; 1994; Frieman and Gillings 2007; Lake *et al.* 1998; Llobera 1996; 2006; 2007a; 2007b; Loots 1997; Wheatley and Gillings 2000); and the application of visibility analysis to specific archaeological questions where the visibility of a given feature or features is significant to the question at issue (Briault 2007; Chapman 2005; Doyle *et al.* 2012; Exon *et al.* 2000; Gillings 2009; Lock and Harris 1996; Patterson 2008; Ruggles *et al.* 1993; Supernant 2014; Wheatley 1995; 1996; Zhang *et al.* 2013).

[50] For criticism of phenomenological approaches to landscape and visibility see Barrett (2004); Barrett and Ko (2009); Brück (2005); DeBoer (2004); Fleming (1999; 2005; 2006); Johnson (2006); Meskell (1996); Renfrew (1994a, 6); Tarlow (2000, 719); and Watson (1990).

[51] For criticism of GIS see Brück (2005); Chadwick (2004, 21); Chapman and Geary (2000); Cummings (2008); Cummings and Whittle (2004, 21–22); Gidlow (2000); Thomas (2004, 171, 198–201); and Tilley (2004b).

[52] See for example Gillings (2009); Lake and Woodman (2003); Tschan (*et al.* 2000); Wheatley and Gillings (2000); and Witcher (1999).

[53] For efforts to integrate a more theoretically sensitive approach into GIS research see Criado Boado and Villoch Vasquez (2000); Fitzjohn (2007); Gillings (2009); Hamilton *et al.* (2006); and Lake (2007).

Experiential Theory in Archaeology' and multiple papers considered methods of integrating theoretical qualitative approaches into GIS analysis of landscape (McEwan and Millican 2012). Some of these methods made explicit use of phenomenology alongside GIS and other computer processes,[54] although Lake (2007) has previously expressed doubts about this and Gillings (2012) suggested that GIS researchers should seek alternative theoretical frameworks applicable to GIS studies of landscape.

Many archaeologists employing phenomenological approaches to landscape have also sought to address the criticisms of their theoretical foundation and method,[55] through explicit methodologies with detailed records of what was seen and from where,[56] and experimentation with multi-vocal accounts and variable imagery.[57] Another approach is to encourage a more reflexive dialogue between researcher and evidence, contextualising phenomenological material to avoid more fanciful interpretations.[58] This latter approach is consistent with the integration of hermeneutic concepts into archaeological theory, wherein all possible sources of contextual evidence are brought together in a dialogue incorporating the researcher, the data, the archaeological and historical context, the foundational archaeological theory or political position underlying the research and any other relevant opinions.[59] Crucially for the debate between phenomenological and GIS approaches to visibility, hermeneutic dialogue allows scientific analysis to be incorporated into the research without dominating it, since scientific analysis and testing must be interrogated in the context of the other available evidence, theories and opinions.[60]

The adoption of hermeneutics and related concepts by some of those employing phenomenological approaches to landscapes therefore undermines opposition to GIS on the basis of its scientific or philosophical origins. Since the inclusion of heterogeneous sources

---

[54] These papers included Eve (2012); Llobera (2012); McEwan (2012); Rennell (2012).
[55] Although see Barrett and Ko (2009) for an alternative view, that improved understanding and proper application of the underlying philosophy will resolve the problems.
[56] For example Cummings and Whittle (2004) and Hamilton *et al.* (2006).
[57] Bender *et al.* (2007) experiment with multi-vocal descriptions and variable imagery in a book that seeks to publish the experience of excavation as much as the results.
[58] Both Tilley (2004a, 219–225; 2008b, 271) and Thomas (1996, chapter 3) have argued that the nature of the archaeological remains place constraints upon phenomenological interpretation. Shanks and Tilley (1992, 104) make a similar point about archaeological interpretation in general.
[59] For contextual archaeology and hermeneutics see Hodder (1992, 188–193); Hodder and Hutson (2003, 156–205); Johnsen and Olsen (1992); Jones (2002, 38) and Shanks and Tilley (1992, 104–110). Thomas (2004, 235–43; 2008, 304–5) has suggested that a similar method of contrast and comparison may assist in reducing the impact of the subjective observer in phenomenological approaches to landscape.
[60] Hodder (1992, 188); Hodder and Hutson (2003, 239–240); Jones (2002, 8 and 38); and Wylie (1992a).

of data, evidence and theories can enhance the credibility of the argument,[61] it could be argued that failing to employ GIS actually undermines the thoroughness of the resulting research, as well as the researcher's dedication to a thorough dialogue with all possible evidence. In view of this, while this author appreciates Gillings' (2012) frustration with the difficulty of creating common ground between researchers using phenomenology and those using GIS, she does not believe with him that it is necessary to abandon previous efforts and seek an entirely new theoretical foundation for GIS research.

1.4. The approach and originality of this research

This research follows a broadly hermeneutic approach; embracing a wide variety of sources of evidence in seeking a better understanding of non-formal structures. In addition to existing archaeological and textual evidence, GIS visibility analysis and evidence derived from the author's experience of visibility form the key sources for interpretation. Other evidence has been incorporated into the investigation as appropriate, including satellite imagery, archaeological evidence and historical, social and religious data relating to Egyptian culture in general and the Middle Kingdom in particular.

This research has been inspired by those who have investigated visibility using GIS technology at a variety of sites across Europe, the Middle East and the Americas. The author's initial GIS analysis of the cairns and courts on Stelae Ridge entailed questions of what was visible from them and where they were visible, which had been influenced by ideas of 'affordance' originally adapted by Llobera (1996), and later developed by Gillings (2009; 2012, 609), who suggested that viewsheds should be considered ways of investigating rather than physical representations of what ancient peoples saw or experienced. This research takes the idea of viewsheds as tools for investigating and develops it by adding stages of interrogation and interpretation using evidence from other archaeological, textual and historical sources, followed by additional visibility analysis to further investigate the results of that interpretation.

In addition to drawing inspiration from GIS-based visibility analysis, this research also takes account of the embodied experience of visibility to corroborate and interrogate the results of the GIS analysis. In this respect, it draws upon both phenomenological research and investigators working with Egyptian material, who have identified a number of visual

[61] See Wylie (1992b; 2000) for how evidence reliant on different theories can make interpretations more compelling; Hodder and Hutson (2003, 200) summarise her approach.

metaphors and references to the natural landscape in Egyptian symbolism, imagery, scripts, iconography and architecture.

Although a number of approaches, methods and theories have influenced this research, it represents a departure from them and a new direction in Egyptian archaeology. It incorporates both GIS and phenomenology, which have been largely ignored by most archaeologists working with Egyptian material and which are often seen as mutually incompatible. Evidence from these approaches is contextualised using existing archaeological and epigraphic evidence, together with a comprehensive body of historical, cultural, religious and social literature from the period, in an effort to obtain a better understanding of a class of non-formal structures, previous interpretation of which has been limited.

1.5. Stelae Ridge: A case study

It has been suggested that an investigation of the visual properties of non-formal structures at Middle Kingdom mining and quarrying sites could provide new evidence for the interpretation of each site individually and the sites as a group. Given the limitations of undertaking this type of GIS-based research in Egypt[62] and constraints of time and funding, this research focuses on a single case study with the aim of determining if visibility analysis can truly provide new approaches to interpretation and understanding of these sites and, if so, to assess what types of questions might be investigated through it.

The site of Stelae Ridge has been chosen for the case study for both technical and practical reasons. Stelae Ridge is not the most extensive or the best documented of the known sites with non-formal structures, but it is also not the smallest. Unlike Hatnub or Serabit el-Khadim its archaeological features are located within a relatively small area, making survey and visibility analysis easier. There is also some textual and artefactual evidence from the site, which can assist in contextualising the visibility analysis. This evidence is largely consistent with similar material from other sites, making it unlikely that Stelae Ridge is particularly abnormal.

Practically, it is a site which is accessible to the author for survey and phenomenological research.[63] It received some historic survey and recording by Engelbach (1933; 1939) and

[62] There are restrictions on access to detailed modern contour maps, particularly of military areas, certain types of remote sensing, such as LiDAR and some aerial photographs are either entirely forbidden or difficult to obtain permission for. Archaeological survey and excavation require official government permission as well as funding for equipment, transport, travel, food and accommodation.
[63] Thanks to Ian Shaw and Elizabeth Bloxam of the Gebel el-Asr Project.

Murray (1939), including useful sketch maps and a sketch plan of the structures on Stelae Ridge. It has also been investigated more recently by Harrell and Brown (1994) and the Gebel el-Asr Project.[64] The latter researchers undertook a survey using a differential GPS accurate to 5m and kindly provided the results to the author. Although there are some disadvantages, chiefly the damage to the site resulting from construction of nearby roads and canals, there are problems associated with all the potential sites and overall Stelae Ridge is the best candidate for this case study.

1.6. Organisation of the thesis

This thesis is divided into two volumes. The first contains the front matter and four chapters. In addition to this introduction, Chapter 2 details the overall methodology and specific techniques used in the visibility analysis. Chapters 3 and 4 comprise the results of the preliminary research undertaken prior to the visibility analysis. Chapter 3 presents research into the archaeological remains at Stelae Ridge. Chapter 4 presents research into the Middle Kingdom landscape at the site, including the climate, the digital elevation model (DEM) of the topography and the history of the modern changes to the landscape. Volume 2 contains the visibility analysis, interpretation and conclusions and bibliography. Chapter 5 details the results of the systematic GIS visibility analysis of the Stelae Ridge cairn-courts. Chapter 6 contextualises the results of the visibility analysis using the archaeological, textual, historical and landscape context of the site. Chapter 7 concludes with an overview of the results, assesses the utility of this approach for investigating non-formal structures at other sites and discusses possible avenues for future research.

[64] For the Gebel el-Asr Project work see Bloxam (2000; 2003a; 2003b; 2005); Heldal *et al.* (2009b); Shaw (2000a; 2003) Shaw and Bloxam (1999); Shaw *et al.* (2001; 2010) Shaw and Heldal (2003).

2. Methodology

This chapter presents the detailed methodology for the visibility analysis of Stelae Ridge, following the background and approach discussed in Chapter 1. The chosen method draws upon current theoretical, archaeological and GIS techniques. It is broadly hermeneutic and involves multiple sources of evidence in an effort to learn more about the Middle Kingdom structures at Stelae Ridge and improve understanding of them. If this research is successful it will offer a new method of analysing non-formal structures, such as those at Middle Kingdom mining and quarrying sites, where interpretation has previously been limited by a lack of archaeological or textual evidence.

2.1. Background and preliminary research

Evidence from previous excavation and survey, translations of the texts from the site and satellite imagery from 1968 onwards provides the foundation for the current research.[65] Archaeological evidence for the dating and chronology, layout and focus of the Stelae Ridge structures was collected and analysed and is presented in Chapter 3. When combined with evidence from satellite imagery, Gebel el-Asr Project GPS survey and archaeological survey undertaken at the site in 2012, the archaeological evidence provided important data and parameters for the visibility analysis. Most significantly, the 2012 survey provided new evidence for georeferencing Engelbach's sketch plan of Stelae Ridge,[66] the only plan of the archaeological features made prior to the modern damage to the site.[67] This was crucial, since that georeferenced plan provides the observer and target locations, detailed in section 2.5, for the visibility analysis of the Stelae Ridge structures.

The preliminary research also included an assessment of the resolution and accuracy of the digital elevation model (DEM) that provided the landscape model for the GIS visibility analysis. Research was undertaken into the sensitivity of the chosen DEM to changes in

---

[65] The results of this preliminary research are presented in Chapter 3 and Chapter 4.
[66] Georeferencing refers to the process of projecting unreferenced raster data onto a known coordinate system, so that it appears in the correct location with the right coordinates in the GIS. This usually involves correlating the unreferenced raster with other data, located on a known coordinate system. For georeferencing in general see Conolly and Lake (2006, 86–88).
Engelbach's (1939, pl. LIV) sketch plan of the eight Stelae Ridge cairn-courts is discussed in Chapter 3, section 3.2. The process of georeferencing this plan is discussed in Chapter 3, section 3.9.1.
[67] For the damage that has occurred to the site in modern times see Shaw (2010, 302–303) and Storemyr (2009, 114), the discussion in Chapter 3, section 3.1 and 3.5–3.7 and the evidence from satellite imagery presented in Chapter 4, section 4.5.

observer height and into how well this model represented the Middle Kingdom landscape, in terms of climate, ecology and topography. This research is presented in Chapter 4.

2.2. Satellite imagery

Free satellite imagery provides a consistent source of information on the landscape and changes to sites over the last 50 years.[68] Five different types of satellite imagery were used in this project, including two different DEM derived from multi-spectral satellite imagery[69] and three other sources of satellite imagery, which provided information concerning the location and layout of the site and the history of recent damage to it.

Only those aspects of the satellite imagery that are of relevance to this research are discussed here. Other types of information are available from the cited sources.

2.2.1. CORONA

High resolution satellite photographs taken by the United States military CORONA KH-4B satellite in 1968 show the location of Stelae Ridge and three of the cairns on the site.[70] The CORONA images were obtained from the Centre for Ancient Middle Eastern Landscapes (CAMEL) of the Oriental Institute Chicago[71] and the University of Arkansas' Centre for Advanced Spatial Technologies (CAST) CORONA atlas of the Middle East.[72]

The CORONA imagery was obtained from CAST as high resolution images, digitised from the originals at 7µm (3600dpi). Ground resolution was *c.* 1.8m,[73] and the files had already been georeferenced by CAST.[74] Imagery from CORONA satellites exhibits variations in scale and increased distortion further from the centre of the image.[75] Casana *et al.* (2012) indicate that the error can reach 20–80m at the edges of orthorectified CORONA images.

---

[68] For a review of available satellite imagery see Parcak (2009, 41–80). For examples of the use of satellite imagery in landscape archaeology where other sources are limited see Bubenzer and Bolton (2013); Chapman (2006, 58); Conolly and Lake (2006, 66–72); Fowler (1996); Phillip *et al.* (2002); and Ur (2003).
[69] Other studies which have used DEMs derived from multi-spectral satellite imagery include Golchale and Bapat (2006); Jennings and Craig (2003); Komatsu *et al.* (2006); Ostir and Nuninger (2006); and Yugsi *et al.* (2006).
[70] For further details of the CORONA, KH-7 and KH-9 missions see Casana and Cothren (2008, 733); U.S. Geological Survey (2008) http://pubs.usgs.gov/fs/2008/3054/ and https://lta.cr.usgs.gov/declass_1, last accessed 15th July 2013.
[71] http://oi.uchicago.edu/research/camel, last accessed 19 March 2014.
[72] http://corona.cast.uark.edu/index.html, last accessed 19 March 2014.
[73] Ground resolution and other specifications for CORONA are recorded on the USGS website http://eros.usgs.gov/satellite-imagery, last accessed 15th July 2013.
[74] For methods of georeferencing and orthorectification used by the Arkansas Centre for Advanced Spatial Technologies (CAST) CORONA Atlas of the Middles East see Casana *et al.* (2012).
[75] Casana and Cothren (2008, 735); Hamandawana *et al.* (2007, 8–10); and Parcak (2009, 56).

Stelae Ridge is located *c.* 28km from the western edge or *c.* 84.5km from the midpoint of the CORONA strip, which is *c.* 225km across. Therefore the Stelae Ridge area of the image is likely to be subject to a certain amount of distortion.

2.2.2. Landsat

Multi-spectral satellite imagery has been acquired using Landsat satellites since 1972 and can be obtained from the United States Geological Survey (USGS) via Earthexplorer.[76] All the Landsat satellites carried a series of scanners, which recorded different spectral bands at varying ground resolutions from 15m to 100m.[77]

Georeferencing was undertaken by the USGS during the processing of the images using the Level 1 Product Generation System (LPGS).[78] All Landsat data is processed to correct for systematic radiometric and geometric inaccuracies. Where ground control points and DEM are available, data are also processed to ensure topographic accuracy. The Landsat imagery used in this project has either been processed to level 1T (Standard terrain correction) or level 1G (Systematic correction).[79] According to the USGS the positional accuracy of Landsat images is equivalent to a Root Mean Square Error (RMSE)[80] of <100m for Multi-Spectral Scanner (MSS) imagery, <50m for Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) imagery,[81] although images processed to L1T would generally have a higher positional accuracy than those processed to L1G.

2.2.3. Quickbird

Most high resolution satellite images are beyond the budget of this research, but sufficient funding was available to purchase 25km^2 of archive high resolution Quickbird satellite imagery from Digitalglobe[82] through European Space Imaging.[83]

The Quickbird satellite image of Stelae Ridge was taken on 13 January 2009 by the Quickbird satellite and was purchased as 4-band pansharpened ortho-ready standard imagery. In this format, the visual information of the multispectral bands are combined with

---

[76] http://earthexplorer.usgs.gov, last accessed 20 October 2014.
[77] For details of bands and resolution see http://landsat.usgs.gov/band_designations_landsat_satellites.php, last accessed 27 August 2013.
[78] Details and parameters for the LPGS are detailed at http://landsat.usgs.gov/Landsat_Processing_Details.php, last accessed 29 August 2013.
[79] Information on correction levels from http://landsat.usgs.gov/Landsat_Processing_Details.php, last accessed 19 November 2013.
[80] RMSE reflects the average spatial error of the rectified satellite image (Conolly and Lake 2006, 82).
[81] See https://lta.cr.usgs.gov/Tri_Dec_GLOO, last accessed 19 November 2013.
[82] http://www.digitalglobe.com
[83] http://www.euspaceimaging.com

the higher resolution spatial information of the panchromatic band to produce a colour product of 0.5–0.6m resolution. The imagery was radiometrically corrected, sensor corrected, georectified and projected for inclusion in image processing software,[84] in this case on the Universal Transverse Mercator (UTM) projected coordinate system zone 36N (hereafter UTM 36N), using the World Geodetic System (WGS) 1984 datum.[85]

Quickbird imagery has a geolocational accuracy specification of 23m Circular Error 90 (CE90), so any location on the image will be within 23m of its actual horizontal position 90% of the time. This would be equivalent to a RMSE of 10.7m.[86] Orthorectification with the SRTM will improve the accuracy of the imagery to *c.* 4–23m CE90 or RMSE of *c.* 1.85–10.68m,[87] but it is not possible to give a precise figure within the range.

The resolution and quality of the Quickbird image is comparable or better than the best quality free imagery, such as Google Earth, because it is projected on a stable coordinate system, chosen to work efficiently with the rest of the Stelae Ridge data in the GIS.

2.2.4. ASTER

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) was launched on 18 December 1999 on the first Earth Observing System (EOS) satellite, Terra.[88] The multi-spectral ASTER data[89] was used to generate a global digital elevation model (GDEM).[90] The ASTER GDEM version 2 (ASTER GDEM2) was released in 2011 with improved accuracy.

The validation team for the ASTER GDEM2 determined that the elevation error for flat or open land, such as Stelae Ridge, is a standard deviation of 5.9m, or RMSE of 6.1m, representing a mean offset of -0.7m elevation or *c.*1m in open areas. The horizontal error was 0.13 arc-seconds to the west and 0.19 arc-seconds to the north, where one arc-second corresponds to 30m at the equator or 29m at Stelae Ridge.[91] These figures reflect the

---

84 Information on the bands, pan-sharpening, accuracy and product specifications from Digitalglobe (2013a; 2013b, 7).
85 For the UTM projected coordinate system and zone 36N see below section 2.3.1.
86 CE90 can be converted to RMSE using the formula CE90 = RMSE * 2.153 (http://emap-int.com/2010/August/article10.html, last accessed 12 November 2013).
87 For orthorectification of the Quickbird imagery see section 2.3.2.
88 https://lpdaac.usgs.gov, last accessed 30th April 2013.
89 Parcak (2009, 67–70) provides a useful summary of ASTER data, its advantages and potential uses. More detailed information on the components, resolution and metadata of ASTER data is available from https://lpdaac.usgs.gov/products/aster_overview, last accessed 30th April 2013.
90 The process is summarised in https://lpdaac.usgs.gov/products/aster_products_table/astgtm, last accessed 30th April 2013. Further details on the production of the ASTER GDTM are available in Tachikawa *et al*. (2011a) which discusses the improvements made to the second version.
91 For the results of the validation see Tachikawa *et al.* (2011b, 21).

accuracy of the ASTERGDEM2 as a whole and local accuracy may be different. The horizontal resolution was 2.4 arc-seconds, 72m at the equator and 69.6m at Stelae Ridge.

ASTER GDEM2 tiles are provided as a Geographic Tagged Image File Format (GeoTIFF) with geographic co-ordinates referenced to the World Geodetic System 1984 (WGS84) and 1996 World Gravitational Model (EGM96) geoid.[92]

2.2.5. SRTM

The Shuttle Radar Topography Mission (SRTM) was flown by the *Endeavour* space shuttle in February 2000. The Space-borne Imaging Radar-C (SIR-C) and the X-Band Synthetic Aperture Radar (X-SAR) were used to generate topographic data.[93] Following processing at the Jet Propulsion Laboratory and National Geospatial-Intelligence Agency (NGA),[94] the more accurate SRTM version 2.1 (hereafter referred to as 'SRTM') was provided in 2009.[95]

The SRTM data is referenced to the World Geodetic System (WGS) 1984 horizontal datum and the Earth Gravitational Model (EGM) 1996 geoid with the WGS84 ellipsoid.[96] Outside the United States the highest resolution SRTM available is 3 arc seconds,[97] equalling *c.* 90m at the equator and *c.* 87m at Stelae Ridge when projected on UTM 36N coordinate system.

Following the production of the data, several validation exercises were undertaken to assess the error in the SRTM. These are detailed in Rodriguez *et al.* (2005). The errors in absolute and relative height, and geolocation were calculated for individual continents. For the African continent, the geolocation error was 11.9m, the absolute height error was 5.6m and the relative height error was 9.8m, all of which are correct for 90% of the data.

[92] https://lpdaac.usgs.gov/products/aster_overview, last accessed 15 November 2013.
[93] See Farr *et al.* (2007) for a detailed description of the SRTM mission and methods employed. An overview is provided in Parcak (2009, 70–72).
[94] The NGA specifications for the Digital Terrain Elevation Data (DTED) supplied by JPL can be found in the NGA document NGA (2000). The processes and rules governing the post-processing of SRTM version 1 into SRTM version 2 are given in NGA (2003).
[95] http://dds.cr.usgs.gov/srtm/ or http://earthexplorer.usgs.gov/, last accessed 20 October 2014.
[96] https://lta.cr.usgs.gov/SRTM2, last accessed 18th July 2013.
[97] This represents a derivation of the original 1 arc second data according to *SRTM_Topo* documentation on http://dds.cr.usgs.gov/srtm/version2_1/Documentation/, last accessed 10 October 2014. From 23 September 2014, 1 arc second data is being released for the rest of the world, but this release was too late for this research (http://www2.jpl.nasa.gov/srtm/, last accessed 20 October 2014).

2.3. General GIS equipment and techniques

The data for this research was located, manipulated and analysed in ESRI's ArcGIS programme. Some functions were undertaken in Quantum GIS (QGIS) when the author was in Egypt, because the terms of the ArcGIS license prohibited use outside the UK.[98]

2.3.1. Map projection and coordinate system

Throughout the GIS research, the UTM 36N projected coordinate system was used to project the data. The UTM projection projects WGS84 geographic coordinates onto a flat plane as a series of zones using a secant Transverse Mercator projection. Stelae Ridge falls within UTM zone 36 North.[99] Within the UTM zone, the horizontal position of the features is described using two-dimensional Cartesian coordinates.[100] The UTM projection is ideal for many GIS projects, including this one, because it is conformal,[101] results in minimal distortion of scale and distance and has a metric coordinate system.

2.3.2. Georeferencing and orthorectification

Maps and plans created in the 1930s by Engelbach (1933; 1939) required georeferencing once they had been loaded into the GIS software, to ensure they were located on the UTM 36N coordinate system, could be compared with other data and provide information for the visibility analysis. Georeferencing involved the identification of common control points in both Engelbach's maps and other data with known UTM 36N coordinates. At least four control points are necessary to permit the computation of the Root Mean Square Error (RMSE) for the rectified raster. Georeferencing was undertaken in the GIS software using the 'Georeferencer' toolbar'.[102]

Orthorectification is the process of removing elevation related distortion from data (Conolly and Lake 2006, 296). Raster maps require orthorectification because they show the surface of the earth as a continuous flat surface, when it is actually of variable height. As received,

---

[98] For ESRI ArcGIS see http://www.esri.com/software/arcgis, last accessed 19 March 2014. For QGIS see www.qgis.org, last accessed 17 October 2014.
[99] See UTM zone map of the world http://www.dmap.co.uk/utmworld.htm, last accessed 04 July 2013.
[100] For an overview of the UTM projection see Conolly and Lake (2006, 20–21) and the NGA (2002) More details of the UTM projection and its relationship with WGS84 can be obtained from the US Defense Mapping Agency (DMA 1990, chapter 2).
[101] Conformal map projections preserve the 90˚ angle between lines of latitude and longitude and therefore the angles between other features on the ground. All Mercator projections are conformal (Conolly and Lake 2006, 20).
[102] For details of the ArcGIS georeferencer toolbar see http://resources.arcgis.com/en/help/main/10.1/index.html, last accessed 17 October 2014.

the CORONA and Quickbird satellite imagery were projected to a constant base elevation. To improve the horizontal accuracy of these images they were orthorectified in ArcGIS using the SRTM DEM.

2.3.3. Multi-spectral satellite imagery

The Landsat imagery comprised varying numbers of multi-spectral bands, which record different parts of the electromagnetic spectrum.[103] When working with these images the bands were examined to determine which provided the best visibility of the landscape and features. Where available, the 15m resolution panchromatic band was chosen since it has the best resolution and was able to show important features not visible to the other lower resolution bands. The chosen bands were then subjected to basic manipulation through the creation of histograms and contrast stretching, to improve the contrast and increase the clarity of the landscape and archaeological features (Lillesand *et al.* 2004, 492–9; Parcak 2009, 64).

No other multi-spectral techniques were used.[104] Current multi-spectral methods are largely limited to prospection and management of archaeological features;[105] require considerable time, resources and experience and do not have direct applications for visibility analysis.[106] The Landsat and Quickbird multi-spectral imagery used in this project were either too low resolution or covered too small an area of the landscape to make multi-spectral techniques worthwhile. Most of the archaeological remains on this site are also small surface features, visible to visual inspection of the satellite imagery, so multi-spectral techniques were unnecessary.

---

[103] See Parcak (2009, 82) for an assessment of the potential for multi-spectral imaging using different types of satellite imagery.

[104]For the use of multi-spectral techniques see the summary in Parcak (2009, 89–111). See also Fowler (1994; 1995); Moshier and El-Kalani (2008); Parcak (2004a; 2007a); Ur (2003; 2005); papers in Campana *et al.* (2010) and examples throughout the rest of this section.

[105] For the use of multi-spectral imaging to identify new sites and features see Carr and Turner (1996); Corrie (2011); Doneus and Briese (2006a; 2006b); Eichhorn *et al.*(2005); Etaya *et al.*(2000); Fowler (1994); Garbuzov (2003a; 2003b); Kouchoukos (2001); Ladefoged *et al.* (1995); Lasaponara *et al.* (2012); McHugh *et al.* (1988); Merola *et al.* (2006); Mumford and Parcak (2002); Parcak (2003; 2004b; 2007b; 2010); Rowlands *et al.* (2006); Yakam-Simen *et al.* (1999); and Yuqing *et al.* (2004). For uses associated with site-management see Goosens and Van Ranst (1998); Parcak (2007a; 2009, 205–232); Peterman (1992); and Stewart (2001).

[106] For a summary of the various methods currently used see Parcak (2009, 89–111); Jensen (1996); and Lillesand *et al.* (2004). These techniques are not directly applicable to questions of visibility and are subject to various problems depending on the terrain, environmental conditions topography and geology (Beck *et al.* 2002, Gatsis *et al.* 2001; McManus *et al.* 2002; Okin *et al* 2001; Parcak 2007a; 2009, 83–84 and 176).

2.3.4. Display of satellite imagery in this thesis

There are no standard schema for displaying satellite imagery. The schema used here for the display of the satellite imagery and digital elevation models have been chosen after personal experimentation with the various colour schemes available. Garish or confusing colour schemes were eliminated on screen and remaining colour schemes were assessed on paper for clarity, capacity to display the nuances of the satellite imagery, and contrast with overlying viewshed and vector data. A greyscale DEM, ranging from black for the lowest heights to white for the highest, with contrasting colours for overlying viewsheds and vector data was found to give the best combination of clarity and contrast. All the images presented in this thesis were created by the author in ArcGIS 10.1 unless otherwise stated.

2.4. Methods of GIS visibility analysis

This research makes use of established types of visibility analysis, available within commercial GIS software because it uses the GIS as a tool to provide new data, which will contribute new evidence toward the re-interpretation of the structures at Stelae Ridge. This does not require new software, new GIS algorithms or new statistical techniques, only the systematic application of the existing GIS visibility analysis software to a series of archaeological features and integration of the results of that systematic visibility analysis with other contextual evidence and additional visibility analysis as appropriate.

Visibility analysis using GIS software, which is also known as varying forms of 'viewshed analysis',[107] comprises systematic assessment of inter-visibility between a given observer location, or locations, and the ground level of the surrounding landscape, defined by the values of a digital elevation model (DEM), or digital terrain model (DTM). The results of that assessment are presented as a 'viewshed' showing what is and is not visible from the observer location, or locations. These viewsheds can be compared with the locations of archaeological or topographic features, and their size can also be extracted for quantification of the results.

The viewsheds produced by this visibility analysis are not considered a simplistic representation of visibility as experienced by individuals in Middle Kingdom. Instead they comprise a type of data which reveals patterns of visibility between the individual Stelae Ridge cairn-courts and specific groups of them. It is the interpretation of the meaning of

---

[107] For examples of different types of viewshed analysis see research undertaken by Felleman (1986); Fisher (1991; 1994); Lake and Woodman (2003); Lake *et al.* (1998); Llobera (2006; 2007a; 2007b); Lock and Harris (1996); Loots (1997); Ogburn (2006); Patterson (2008); Ruggles *et al.* (1993); Supernant (2014); Wheatley (1995); and Wheatley and Gillings (2000).

these patterns, in the context of archaeological and textual evidence from the site and elsewhere, which allows the development of new and more detailed interpretations of the Stelae Ridge structures.

2.4.1. Types of visibility analysis

Three methods of visibility analysis were employed in this research, using the 'Visibility' toolset in the ArcGIS 10.1 '3D Analyst' toolbox:[108]

1. Single Viewshed – performed using the 'Viewshed' tool for a single observer location.
2. Cumulative viewshed[109] – performed using the 'Viewshed' tool for up to 16 locations. The resulting viewshed shows how many of the observer locations each DEM cell is inter-visible with, but not which observer locations.
3. Observer points – performed using the 'Observer Points' tool for up to 16 locations. The results show which cells of the DEM are inter-visible with each observer location.

2.4.2. Controlling the visibility analysis

All types of visibility analysis are controlled by the attribute table of the vector point layer containing the observer location or locations.

Table 2.1: Example of an attribute table for eight observer locations and the fields used to control the visibility analysis.

OBJECT ID	Observer Point	SPOT	OFFSETA	OFFSETB	AZIMUTH1	AZIMUTH2
1	OB1	194	1.60	0.00	301.445	198.721
2	OB2	194	1.60	0.00	310.241	227.131
3	OB3	194	1.60	0.00	301.812	233.189
4	OB4	194	1.60	0.00	317.041	206.655
5	OB5	194	1.60	0.00	309.572	210.467
6	OB6	193	1.60	0.00	311.560	211.935
7	OB7	192	1.60	0.00	309.135	228.974
8	OB8	192	1.60	0.00	308.544	239.515

[108] For the tools for visibility analysis in ArcGIS see http://resources.arcgis.com/en/help/main/10.1/index.html#//00q90000008n000000, last accessed 17 October 2014.
[109] Following Conolly and Lake's (2006, 291) definition.

Table 2.1 is an example of an attribute table of a vector point layer containing parameters for the visibility analysis. Each row in the table refers to a different observer point. The different fields control different aspects of the visibility analysis; SPOT dictates ground level at the observer location, OFFSETA gives the height offset above ground level at the observer point location, OFFSETB gives the offset for the rest of the DEM cells, AZIMUTH1 is the angle from which the analysis should proceed clockwise and AZIMUTH2 is the angle where the analysis should stop. The observer points in Table 2.1 give the parameters for a 1.6m observer looking outwards from each observer point towards ground level in the surrounding landscape. OFFSETA is therefore set to 1.6m to reflect eye level of the observer above the ground at the observer point. OFFSETB is set to 0m to reflect ground level at the target points in the surrounding landscape.

A viewshed like the one generated using the values in Table 2.1, showing what is visible from an observer location, is described as ‘projective’. A viewshed showing from where an observer location is visible is described as ‘reflective’, and is not necessarily reciprocal to a projective viewshed.[110] In ArcGIS a reflective viewshed can be calculated by inserting the height of the human observer in OFFSETB and the height of the target in OFFSETA. The resulting viewshed shows where the target at the observer point is visible to a human observer in the surrounding landscape.[111]

2.4.3. Inclusive and exclusive queries

The raster products of observer points analysis can be visually complex when multiple locations are included. In order to assess specific questions and quantify the results, the rasters were queried using the ‘Extract by Attributes’ function of the ‘Extraction’ toolset in the ArcGIS ‘Spatial Analyst’ toolbox.[112]

Queries were structured to identify what was visible from a given observer point or group of observer points and could be either ‘inclusive’ or ‘exclusive’:

1. ‘Inclusive’ queries were structured to identify all the cells visible to a given observer point or points, *including* those which were also visible to other observer points.

---

[110] For reciprocity and projective and reflective viewsheds see Conolly and Lake (2006, 229–230); Loots (1997); and Woodman (2000).
[111] This process and associated concepts are explained in more detail in the ArcGIS 10.1 help in the section *Using Viewshed and Observer Points for visibility analysis* (http://resources.arcgis.com/en/help/main/10.1, last accessed 12 March 2014).
[112] http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//009z00000029000000.htm, last accessed 20 October 2010.

2. ‘Exclusive’ queries were structured to identify the cells which were only visible to a given observer point or points, *excluding* cells that are also visible to other observer points.

2.4.4. Quantifying the visibility analysis

Where appropriate, the area of the viewshed or viewsheds extracted from the observer points analysis could then be calculated in km^2 for comparison with other results. The number of raster cells included in the viewshed was obtained from the raster attribute table and multiplied by 7475.410864 to determine the viewshed area in m^2,[113] this figure could then be divided by 1000000 to obtain the viewshed area in km^2.

2.5. Systematic visibility analysis of the Stelae Ridge structures

The eight cairn-courts located upon Stelae Ridge are the features of greatest interest to this research, because of their parallels with other non-formal structures at quarrying and mining sites.[114] The visibility of and view from the cairns and courts were subject to systematic visibility analysis using the methods described in section 2.4, to provide viewshed data for comparison of the different visibilities of the individual structures and relevant groups of them. The results of the systematic visibility analysis are presented in Chapter 5.

The systematic visibility analysis included projective and reflective cumulative viewshed and observer points analysis of the eight Stelae Ridge courts, and reflective cumulative viewshed and observer points analysis of the eight Stelae Ridge cairns.

The cumulative viewsheds were quantified using the method described in section 2.4.4, to reveal the general patterns within the data and determine the total visible areas (TVA). The total visible area was defined as the total area of the landscape either visible from or with a view of, at least one of the courts or cairns, depending on which structure was being analysed and whether the analysis was projective or reflective.

The inclusive and exclusive viewsheds for each court and cairn, and for specific groups of structures, were extracted from the results of the observer points analyses using the method described in section 2.4.3, and then quantified using the method described in section 2.4.4. The sizes of these viewsheds were calculated in km^2 and as a percentage of the relevant

---

[113] Using the GIS it was possible to determine that each raster cell of the viewsheds was 7475.410864m^2.
[114] See Chapter 1, section 1.2 for non-formal structures at quarrying and mining sites and their interpretation and Chapter 1, section 1.5 for the choice of Stelae Ridge as a case study for the use of visibility analysis to re-interpret them.

total visible area to facilitate comparison between the viewsheds of different structures and groups of structures.

The systematic visibility analysis also included testing of the parameters used to represent the height of the cairns, to model the effect of the cairns upon visibility of the courts (section 2.6.3) and for the observer and target locations (section 2.5.1 and 2.5.2). These tests involved removing or altering these parameters under controlled conditions and comparing the results with the original visibility analysis to assess whether changes to these parameters had any effect upon the results of the visibility analysis and therefore whether the results of the visibility analysis were being determined or heavily influenced by the specific parameters chosen. The results of these tests are presented in Chapter 5. Section 5.2 considers the effect of the azimuths used to model the effect of the cairns upon visibility of the courts. Section 5.4.2 considers the effect of changing the cairn heights used in the visibility analysis and section 5.4.1 considers the effect of slight changes in observer location from court to cairn.

2.5.1. Visibility analysis of the Stelae Ridge courts

The layout of the archaeological remains and artefacts at Stelae Ridge suggested that the courts, or areas in front of the eastern faces of the cairns, formed a focal point where artefacts were deposited and activities took place.[115] The view from the courts or the visibility of them may therefore have been significant in the choice of Stelae Ridge as a location for them and in the positioning of individual structures on Stelae Ridge.

The visibility analysis of the courts included both projective and reflective analyses, so that the view from each court could be compared with how visible it was. The projective visibility analysis assessed where a human observer standing in the court could see ground level in the surrounding landscape.[116] The reflective visibility analysis assessed where a human observer within the landscape could see ground level in the courts. While human participants or artefacts erected in the courts would be more visible than ground level, this reflective visibility analysis provided a baseline for understanding the visibility of the courts and the underlying topography of the ridge.

---

[115] See Chapter 3, section 3.2, particularly section 3.2.4 for discussion of the layout of the archaeological remains.
[116] The height of the human observer was determined based on research into Middle Kingdom stature presented in section 2.6.1.

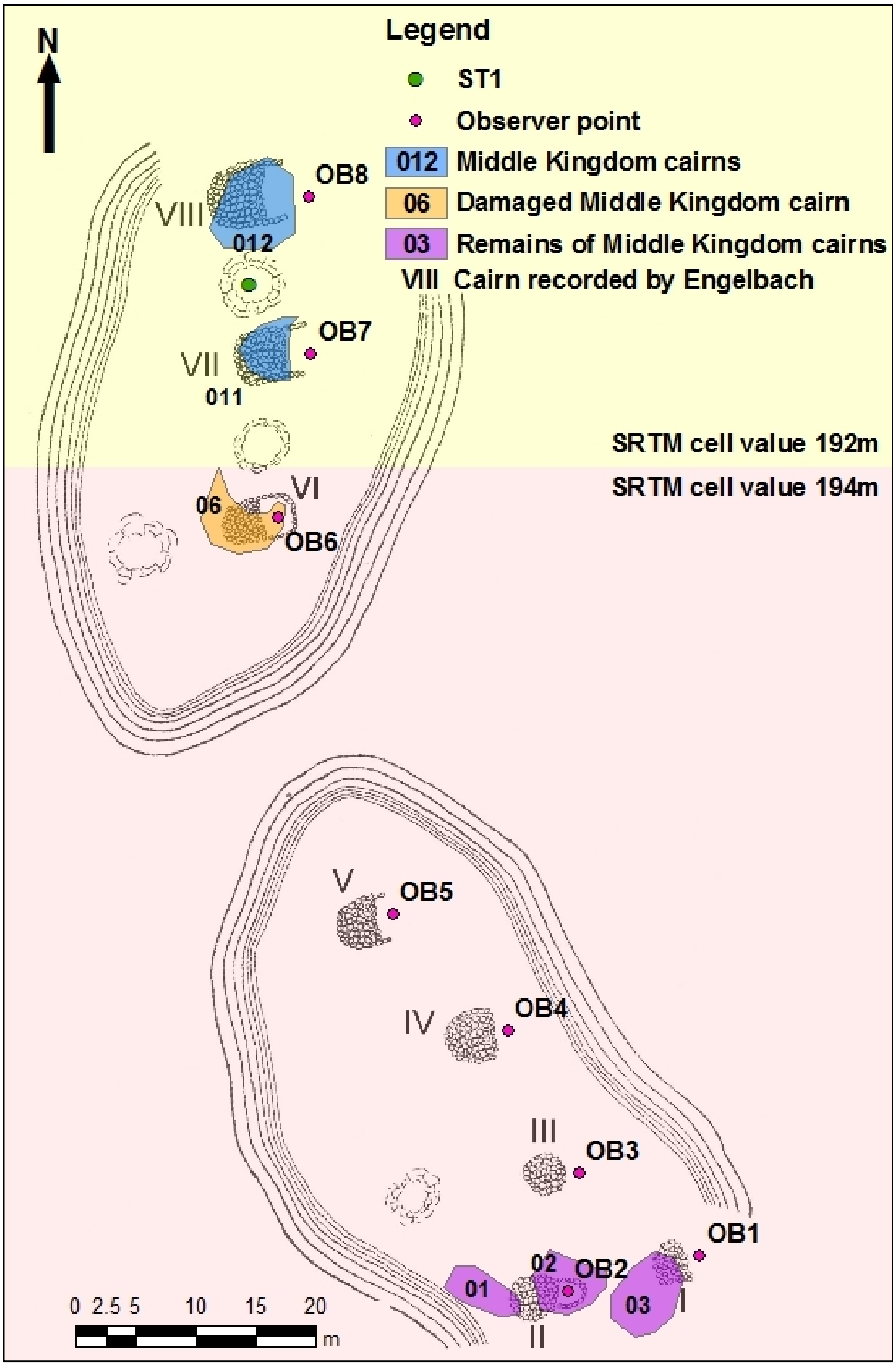


Fig 2.1: Location of the observer points (OB) for visibility analysis of the courts, shown overlying Engelbach's sketch plan and the two SRTM cells with ground levels of 192m and 194m, which cover Stelae Ridge. Coloured polygons with Arabic numerals indicate cairns recorded by the 2012 survey. ST1 is a station used in the 2012 survey. (SRTM data available from the USGS).

Each court was represented by a single vector point, the observer location or observer point, the position of which was determined by the location of the courts as recorded in Engelbach's (1939) sketch plan, incorporated into the GIS as a georeferenced raster during the preliminary research (Fig 2.1).[117]

Fig 2.1 shows that the observer points were located in the courts, as shown on Engelbach's plan. The only exception was court VIII/012 where the observer point was placed further east to allow for the location of the cairn in the 2012 survey. Observer point OB6 in court VI/06 appears partly within cairn 06 as recorded by the 2012 survey because this cairn had been altered and partly demolished recently. On the southern ridge, the 'cairns' recorded during the 2012 survey were identified as modern heaps with no direct relationship to the Middle Kingdom cairns recorded by Engelbach.[118] Where no court was shown on Engelbach's plan, the observer point was placed to the east of the eastern face of the cairn. For consistency, OB3 was located on the eastern side of cairn III, which is the only fully round cairn and does not have either a court or a flat eastern side.[119]

2.5.2. Visibility analysis of the cairns at Stelae Ridge

Since cairns are often associated with landmarks and may be constructed to render a location more visible,[120] the visibility of the Stelae Ridge cairns may reflect additional or subsidiary functions of the cairns as landmarks and provide new insights into the choice of Stelae Ridge or the positioning of the cairns upon it.

As cairns are generally intended to be viewed, only reflective visibility analysis was undertaken to determine from where they could be seen. The reflective visibility analysis assessed where a human observer standing in the landscape around the site could see the Stelae Ridge cairns, represented by a target offset above ground level.[121]

---

[117] See Chapter 3, section 3.9.1 for the georeferencing, the data used, problems and errors in the process and differences between the georeferenced plan and the 2012 survey data.
[118] For the identification of the cairns recorded during the 2012 survey with Engelbach's cairns see Chapter 3, section 3.7.2.
[119] See Chapter 3 section 3.2.4 for a discussion of the differences between cairn III and the other Stelae Ridge cairns.
[120] For cairns interpreted as landmarks, including the Stelae Ridge structures see Chapter 1, section 1.2.2, particularly footnote 25. The possibility that some cairns, particularly cairn III, were primarily intended to function as landmarks is considered in Chapter 3, section 3.2.4.
[121] The height of the human observer was based on research into Middle Kingdom stature presented in section 2.6.1. Section 2.6.3 describes how the target offset for the cairns was determined from the mean heights of the surviving cairns.

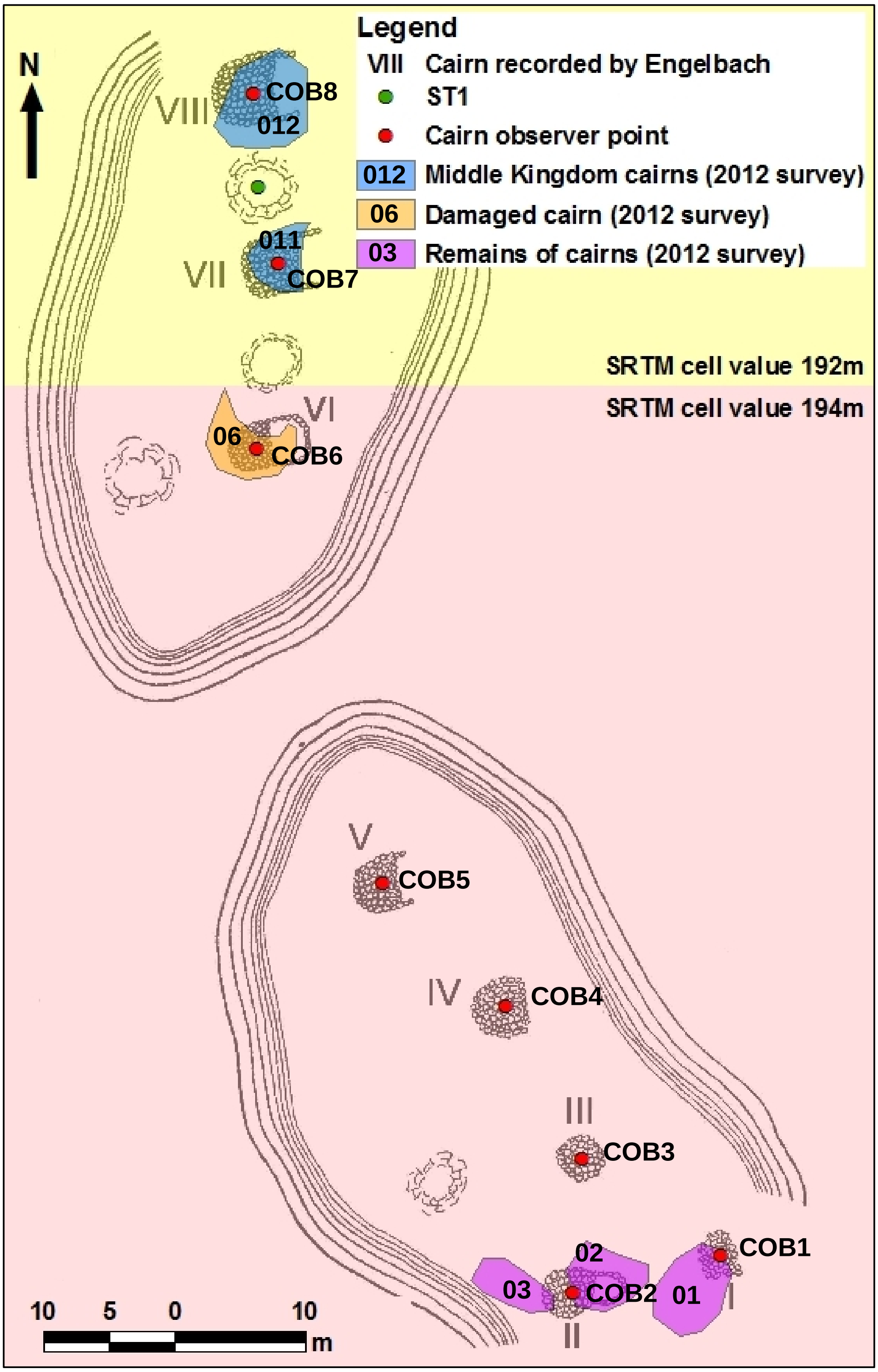


Fig 2.2: Location of the cairn observer points (COB). Coloured polygons with Arabic numerals indicate cairns recorded by the 2012 survey. The figure shows the cairn observer points in relation to the sketch plan made by Engelbach, the 2012 survey and the SRTM cells of SRTM tile n22_e031_3arc_v2 (SRTM data available from the USGS).

As with the visibility analysis of the courts, the observer locations for the cairns were based upon Engelbach's (1939) sketch plan after georeferencing, taking some account of the 2012 survey data and slightly offset towards the flat eastern face of the cairn, where present. This was because the surviving remains of the best preserved cairns suggested that the highest point of the cairns was originally located east of the centre, towards their flat faces. The observer points for visibility analysis of the cairns are shown on Fig 2.2.

2.6. Parameters for the visibility analysis

It is possible to control the visibility analysis using a variety of parameters, input into the attribute table of the observer locations layer.[122] The parameters used and the preliminary research undertaken to obtain them are presented here.

2.6.1. Observer height

The height, or eye level, of the putative observer is a key variable in visibility, since the eye level of an individual will inevitably affect their experience of visibility. Changes in observer height can significantly alter the resulting viewshed (Lock and Harris 1996), but in many examples of viewshed analysis the offset used in lieu of observer height, is not even specified.[123] In others, it is referred to almost in passing, without discussion of the source of the figure or the justification for it.[124] Such examples lend credence to criticisms that GIS studies generally, and viewshed analyses specifically, are dehumanising and overly concerned with technique over the understanding of archaeological evidence (Gaffney and van Leusen 1995; Gillings and Goodrick 1996).

Where the height of the viewer is stated, previous studies have typically used a figure of 1.6–1.75m (Wheatley and Gillings 2000, 7). A figure of 1.7m seems to be popular with some,[125] although Tschan (*et al.* 2000, 42) and Llobera (1996, 619) used a figure of 1.6m. Prior to adopting any specific figure, research was undertaken into the height of Middle Kingdom Egyptians.

Middle Kingdom stature

There have been relatively few investigations of the stature of the ancient Egyptian population and human remains are rare from the Middle Kingdom (Robins 1983, 17). While

[122] See above section 2.4.2.
[123] See for example Lake *et al.* (1998); Llobera (2006; 2007b); and Wheatley (1995).
[124] Gillings (2009); Llobera (1996, 619); Tschan *et al.* (2000, 42); Wheatley and Gillings (2002, 211).
[125] Including Gillings (2009); Wheatley and Gillings (2002, 211).

more Old Kingdom material is now available, particularly from Giza,[126] most studies concern mummies and skeletal material from either the predynastic period[127] or the New Kingdom and later.[128]

Analyses of human remains are often primarily concerned with the number of individuals, their age, sex and any trauma or palaeopathological findings; relatively few investigations of human remains of any period have attempted to determine the stature of their subjects in life.[129]

The limited quantity of Middle Kingdom human remains available for study, combined with the low number of investigations into ancient Egyptian stature, has resulted in limited evidence for the height of Middle Kingdom individuals. Robins investigated the stature of three Middle Kingdom males as part of an assessment of the relationship between natural proportion and the canonical proportions of Egyptian art. These three individuals were found to have heights of 1.67m (Man.21470), 1.65m (Man. 21471) and 1.73m (BM 23425) respectively (Robins 1983, 19). Zakrzewski analysed 22 Middle Kingdom individuals from Gebelein during an investigation into changes in stature from the predynastic to the Middle Kingdom. She determined that the Middle Kingdom males at Gebelein had a mean stature of 1.66m ±0.051m and females had a mean stature of 1.55m ± 0.032m (Zakrzewski 2003, 224). The figure for males is within the range suggested by the three individuals analysed by Robins (1983).

Zakrzewski's figures are slightly higher than the 1.61m mean male height and 1.53m mean female height of 11 Middle Kingdom individuals excavated from tomb A17 in the Theban necropolis by Bellandi *et al.* (2014, 25), perhaps because the sample from tomb A17 was so

---

[126] See for example the Old Kingdom populations investigated by Raxter *et al.* (2008) and Mulhern (2005).
[127] For investigations of predynastic material see for example Batey (2008); Dougherty and Friedman (2008); Greene (2007); Keita (2003); Lovell (1997); and Thompson and Madden (2006). Keita and Boyce (2006) consider Early Dynastic material.
[128] For investigations of New Kingdom and later material see Betrò and Del Vesco (2006); Betrò *et al.* (2007); Buzon (2006); Kaczmarek (2000); Macke *et al.* (2002); Raven *et al.* (2001a; 2001b); Redford (1996); Rose (2006); Strouhal (1995); Strouhal *et al.* (2003); Strudwick (2005); and Zweifel *et al.* (2009). Lovell (1997) also includes Roman material. The various papers in Ikram *et al.* (2014) also cover a wide range of periods.
[129] Studies which take account of ancient Egyptian stature include the analysis of a Neolithic population in Judd (2006); the development of new Egyptian-based regression formulae for the calculation of stature from long bone length in Raxter *et al.* (2008); analysis of predynastic stature (Robins 1983; Robins and Shute 1986) and New Kingdom pharaohs (Robins and Shute 1983); analysis of changing Egyptian stature across time (Masali 1972; Zakrzewski 2003); estimation of the stature of an undated mummy (Piombino-Mascali *et al.* 2014); and thorough analysis of New Kingdom to Roman remains from a tomb in western Luxor (Macke *et al.* 2002).

small and probably represents a related group, rather than a random sample of the population.

Masali (1972, 193) calculated a range of 1.62–1.72m for Dynastic males and 1.53–1.58m for Dynastic females, although it should be noted that Masali did not specify which phase or phases of the Dynastic period these individuals dated to. Masali's figures could therefore reflect stature across a mixture of periods or only one and need not be representative of the Middle Kingdom.

Zakrzewski and Masali's figures are broadly consistent with the skeletal heights quoted by Raxter *et al.* (2008), since skeletal height is always lower than living stature (Fully 1956). Raxter (*ibid*, 149, Fig 1 and 2) did not specify the individual skeletal heights by period for the individuals included in the study, instead grouping all non-Old Kingdom individuals together. Examination of the graphs in Raxter *et al.* (2008) produced ranges of 1.49–1.57m for Dynastic skeletal height in males and 1.34–1.46m for skeletal height in females. Allowing for conversion process suggested by Lundy (1988), this would give living statures of *c.* 1.59–1.68m for males and *c.* 1.44–1.56m for females. It is likely that there is a level of error within the conversion[130] and it should also be noted that the non-Old Kingdom groups included very limited numbers of individuals, of which only four were Middle Kingdom and the remaining 13 dated from the predynastic to the Coptic periods.

The data on Middle Kingdom stature is broadly consistent with studies of stature in other Egyptian periods, particularly with regard to female stature. Prehistoric populations are slightly taller and populations from later periods are shorter. There is a noted decrease in male height in later periods compared to the Early Dynastic and Old Kingdom (Zakrzewski 2003). The currently limited evidence for Middle Kingdom stature suggests a range of *c.* 1.60–1.73m for males and *c.* 1.55m for females. These figures are consistent with those calculated using data covering longer time periods (Masali 1972; Raxter *et al.* 2008) and for the trends in ancient Egyptian stature across all periods.

Observer height for the visibility analysis.

Apart from sensitivity and other tests, the observer height used for the visibility analysis was set at 1.6m. Although at the lower end of the range of *c.* 1.60–1.73m for Middle Kingdom males, this was slightly higher than the *c.* 1.55m for females. The observer height was set on the low side for Middle Kingdom males because this ensured that the results of the analysis

[130] See the discussion in Lundy (1988, 538), which suggests an error of *c.* 0.2–2.2cm is likely.

would be true for a larger proportion of the ancient population than if the observer height had been set at the higher end of the range.

Further analyses with different observer heights could potentially be undertaken to investigate differences in the visibility afforded to observers of different statures, but this has not been undertaken here as the aim is to investigate the properties of the landscape rather than the effect of variation in observer height.

2.6.2. Ground level at the observer locations

Two SRTM cells occupy the site at Stelae Ridge, with a dividing line close to cairn-court VI/06. The northern cell, occupied by cairn-courts VII and VIII, has a height value of 192m and the southern cell, occupied by cairn-courts I-VI has a height value of 194m (Fig 2.1). This is clearly a coarse rendering of landscape and does not have a high enough resolution to model the individual ridges or their remnants. Preferably a more precise measure of the height at any given observer location would have been obtained from a hybrid DTM created from the Stelae Ridge topographic survey, but there was insufficient time to undertake that topographic survey at Stelae Ridge in 2012.[131]

The ground level measurements around the cairns surveyed in 2012 provide a more precise measure of ground level, but current ground level could only be determined for the three surviving cairns on Stelae Ridge north. Since the visibility analysis will necessarily rely upon comparisons of the viewsheds of different cairns or groups of cairns, it is important that the source for the ground level data is consistent for all the observer points. To ensure consistency, the SRTM cell value provided the ground levels at cairn-courts I-V and VII-VIII (Fig 2.1). Cairn-court VI is very close to the division between the SRTM cells. To allow for its proximity to SRTM cell 192m and mitigate the coarseness of the SRTM to some extent, ground level at cairn-court VI was set at 193m.

[131] For the 2012 survey of Stelae Ridge, its aims and results see Chapter 3, section 3.7. For the proposed hybrid DTM see Chapter 4, section 4.2.4.

2.6.3. Heights of the cairns

Ideally, the height of the cairns would be included in the hybrid DTM used to calculate visibility, but this was not possible. Therefore it was necessary to use other methods to determine the height of the cairns for the target offset for the visibility analysis of the cairns and to assess how far they are likely to have impeded visibility from the courts.

The 2012 survey included points taken around the base and on top of the surviving cairns. The difference between the highest surviving point and the lowest surviving point gives some indication of the height of the cairn. The base measurements were differentiated from the top measurements using their elevations (Table 2.2) and their positions relative to each other in the GIS (Fig 2.3). Base measurements formed an outline around the outside edge of the cairn and the top measurements were located inside.

Table 2.2: Base and top heights of cairn VII/011

Point ID	**Height (m)**
Base	
125	192.24010
148	191.46412
149	191.96915
152	192.27267
153	191.87661
154	192.22779
155	192.13780
156	191.76897
157	191.54268
158	191.63318
159	191.56585
160	191.37974
Mean Base height	**191.83989**
Top	
161	193.10243
162	192.95970
Mean Top height	**193.03107**

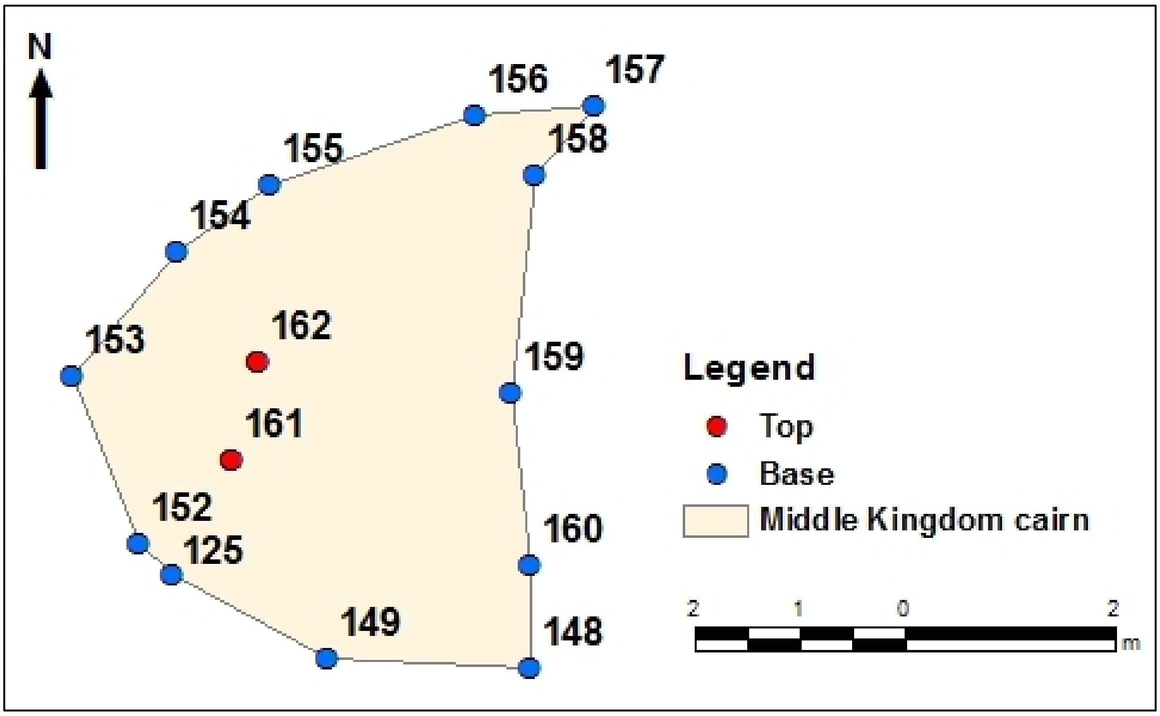


Fig 2.3: Cairn VII/011 from the 2012 survey data, showing the outline of the cairn and the individual measurements with their ‘Point ID’ numbers from Table 2.2.

The difference between the mean base measurement and mean top measurement was then calculated. Table 2.2 and Fig 2.3 demonstrate the process for Cairn VII/011. First the GIS was examined to determine the readings taken on top of the cairn and those taken around the base. Then these were separated and the mean base height and mean top height were calculated.

Target offset for visibility analysis of the cairns

Table 2.3 gives the mean height difference between the base and top of the three surviving cairns. Cairn 011 (Engelbach's VII) and 012 (VIII) were reasonably well preserved and, although it is possible some height had been lost from them, their surviving heights represent the best evidence for the height of the original cairns. Cairn 06 (Engelbach's VI) had been modified by modern damage and is likely to have been both a different shape and higher.[132] Since the three surviving 'cairns' on Stelae Ridge south bear no relationship to the original structures and Engelbach made no record of the heights of the cairns, the mean height (1.28m) of the two best-preserved cairns was used as the target offset (OFFSETA) for all the cairns.

A second visibility analysis of the cairns was undertaken using the surviving mean heights of 1.19m and 1.36m for cairns VII/011 and VIII/012 respectively, to assess whether this would affect the results of the visibility analysis. The results of this are presented in Chapter 5, section 5.4.2 and revealed that changing the target height of these cairns had almost no effect on the conclusions drawn from the visibility analysis.

Table 2.3: Heights of the best preserved Stelae Ridge cairns, showing the differences between the mean base and mean top heights.

Cairn No		Height (m)		
Engelbach	2012 Survey	Mean top	Mean base	Mean difference
VI	6	192.51	191.60	0.91
VII	11	193.03	191.84	1.19
VIII	12	192.55	191.19	1.36

Further visibility analysis of the visibility of ground level beneath the cairns was also undertaken, using a target height of 0m, for comparison with both the visibility analysis of the cairns and the visibility analysis of the courts.[133]

[132] For the relationship between the structures surveyed in 2012 and the cairns recorded by Engelbach see Chapter 3, section 3.7.2.
[133] The results of the visibility analysis of ground level beneath the cairns are presented in Chapter 5, section 5.4.1. They were broadly similar to the results of the visibility analysis of the cairns and courts but there were some interesting differences.

Impact of the cairns upon visibility analysis of the courts

The presence of the cairns would potentially limit visibility of the courts and views from them. Table 2.3 shows that the surviving heights of the three best preserved cairns would not have been sufficiently high to obscure the view from any observer of normal Middle Kingdom adult height of 1.55–1.73m. It is possible that they were originally higher, but if so and how high it is not possible to determine.

While the cairns may not have directly obscured the physical view to the west, they could have had an impact on which areas of the viewshed an individual focussed upon. The sheer bulk of the cairns would have provided an impressive backdrop that focussed attention on the area within the court and not upon the landscape to the west of the cairns.

It should also be remembered that the cairns would have had a greater impact upon visibility of the courts than views from them, because they are located on a ridge and so would generally have been viewed from lower areas of the landscape. Even a relatively small rise in the ground between the observer and the target can obscure ground level at the latter, when it is higher than ground level at the observer's location.

It is not possible to include the cairns as topographic features in the DEM, but some assessment of their impact upon visibility, either physical or psychological, can be made by limiting the angle of the viewshed analysis. By altering the AZIMUTH1 and AZIMUTH2 fields of each observer point in the attribute table, the angle occupied by the relevant cairn can be excluded from the viewshed analysis.

To determine the correct angles for each set of azimuths, vector lines were first created from each observer point to the edge of the cairns, as recorded on Engelbach's plan. Fig 2.4 demonstrates the process with regard to cairn VII/011 and observer point OB7. It is recognised that there is a subjective element to this process, but considering the lack of data for modelling the cairns in the DEM and the desire to take some account of their impact upon visibility, this was considered the most appropriate option. Fig 2.5 shows the azimuths created for all the cairns.

The 'Polyline Get Azimuth' tool of Easy Calculate 10[134] was then used to calculate the azimuth at the start of each line. Table 2.4 shows each observer point, its two azimuths and the angle excluded from the visibility analysis. At cairn VII/011, AZIMUTH1 is 309.135° and

---

[134] Easy Calculate 10 is a free open source add in for ArcGIS 10 that allows calculations to be made in the attribute table of a vector layer. It can be obtained from http://www.ian-ko.com/, last accessed 17 June 2014.

AZIMUTH2 is 228.974° and the viewshed analysis will include only the area clockwise from 309.135° to 228.974°, effectively excluding the 80.16° area occupied by the cairn.

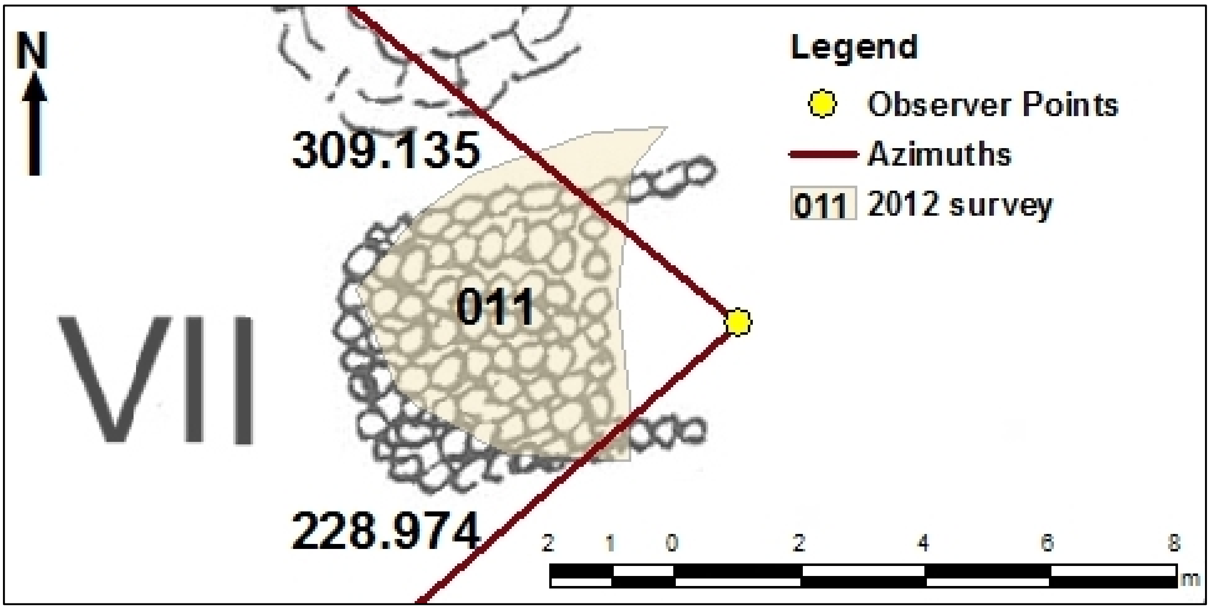


Fig 2.4: Cairn VII/011 showing the azimuth vector lines from OB7 to the edges of the cairn. The bearings of the azimuths are shown next to the relevant line.

Table 2.4: Azimuths and angles excluded from the visibility analysis for each observer point.

Observer Point	Cairn number		AZIMUTH 1	AZIMUTH 2	Excluded Angle (°)
	Engelbach	2012 Survey			
OB1	I	3	301.445	198.721	102.72
OB2	II	2	310.241	227.131	83.11
OB3	III	N/A	301.812	233.189	68.62
OB4	IV	N/A	317.041	206.655	110.39
OB5	V	N/A	309.572	210.467	99.11
OB6	VI	6	311.56	211.935	99.63
OB7	VII	11	309.135	228.974	80.16
OB8	VIII	12	308.544	239.515	69.03

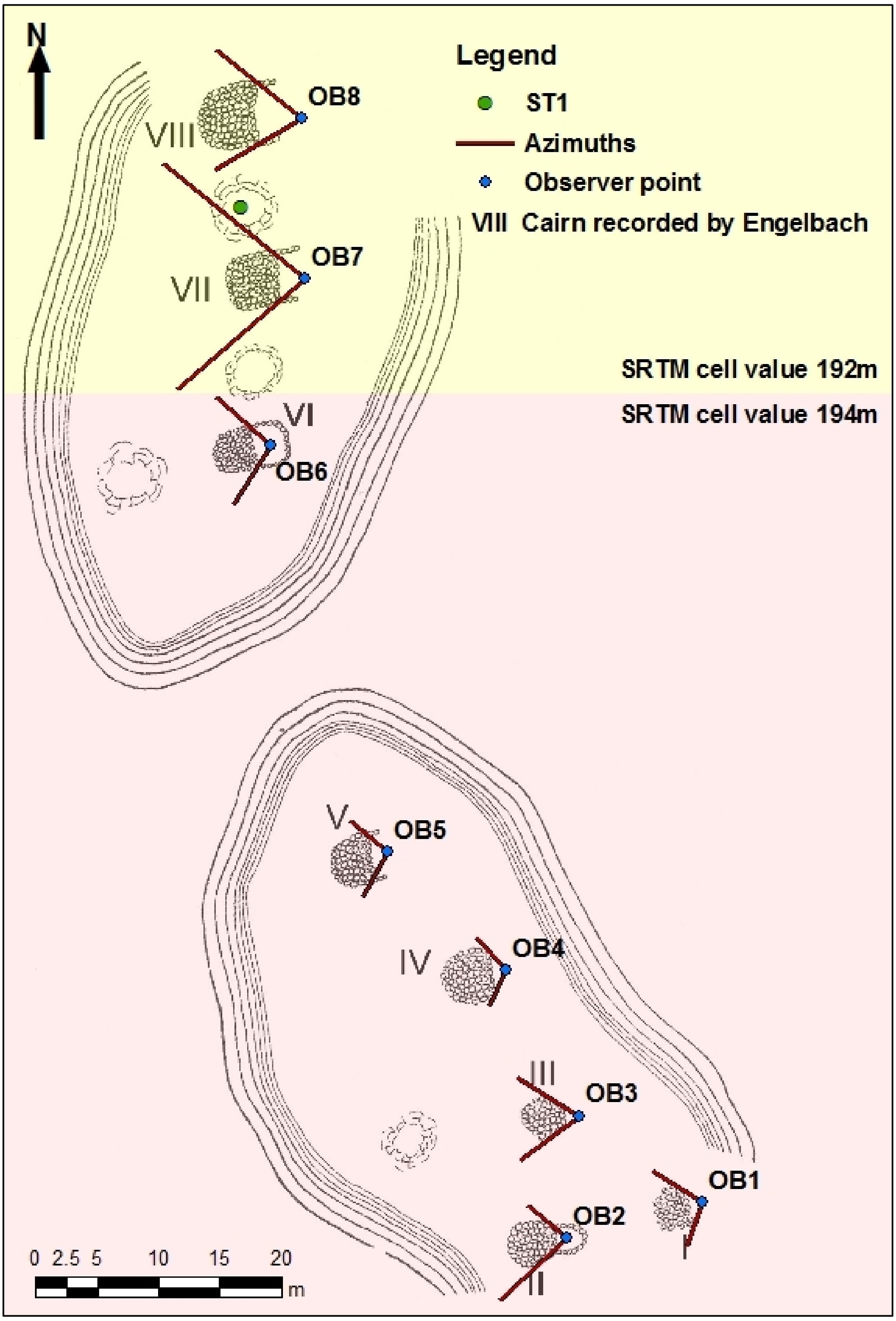


Fig 2.5: The azimuths created for all the cairns. Note that the length of the azimuth lines is irrelevant in the calculation. It is the angle at the observer point that is significant. The figure shows the observer points in relation to the sketch plan made by Engelbach and the SRTM tile n22_e031_3arc_v2 (SRTM data available from the USGS).

It is recognised that this method is not ideal. Alterations to the precise location of the azimuths generated for each cairn would have minimal effect upon a viewshed generated from the SRTM because of the low resolution of the DEM, but the method also fails to take account of the sloping sides of the cairn, which would obscure less of the view than the central part. The azimuths are also based upon Engelbach's sketch plan, which is associated with possible georeferencing errors. However, in the absence of a topographic model of the surviving cairns, or any model of the lost ones, it can provide some idea of the possible physical or psychological restrictions to the viewshed resulting from the nearest cairn to each court.

It should be noted that only the cairns closest to each court can be modelled in the visibility analysis in this way. No attempt has been made to take account of the effect of the other cairns upon the viewsheds for the observer point in any given court. This is partly due to the limitations of the AZIMUTH function, but it also reflects uncertainty about the original heights of the cairns and their precise impact upon visibility. Psychologically, the focus of observers located in a court would be most affected by the nearest cairn; and increased distance from the other cairns would also limit their physical impact upon visibility.

To assess the effect of the azimuths upon visibility analysis of the courts, cumulative viewshed and observer points analysis of the courts were also undertaken without azimuths.[135] This revealed that although the azimuths did have some effect upon the results of the visibility analysis, particularly upon the ranking of the courts by viewshed size, most of the conclusions drawn from it were consistent whether azimuths were used or not. No azimuths were employed in the visibility analysis of the cairns.

2.6.4. Individual parameters for each of the courts and cairns.

The individual parameters for each observer point in each court on Stelae Ridge are listed in Table 2.5 below. Table 2.5 shows the parameters for projective visibility analysis with azimuths. Reflective visibility analysis entailed swapping the figures in OFFSETA and OFFSETB. The parameters for each observer point representing each cairn are listed in Table 2.6. Other factors which affect visibility generally, including the curvature of the earth, atmospheric refraction and visual range are considered in the next section.

---

[135] For the results of this see Chapter 5, section 5.2.

Table 2.5: Observer points OB1-OB8 in the courts on Stelae Ridge

Observer Point	Court number Engelbach	2012 Survey	SPOT	OFFSET A	OFFSET B	AZIMUTH 1	AZIMUTH 2
OB1	I	03	194	1.60	0.00	301.445	198.721
OB2	II	02	194	1.60	0.00	310.241	227.131
OB3	III	N/A	194	1.60	0.00	301.812	233.189
OB4	IV	N/A	194	1.60	0.00	317.041	206.655
OB5	V	N/A	194	1.60	0.00	309.572	210.467
OB6	VI	06	193	1.60	0.00	311.560	211.935
OB7	VII	011	192	1.60	0.00	309.135	228.974
OB8	VIII	012	192	1.60	0.00	308.544	239.515

Table 2.6: Observer points COB1–COB8 at the Stelae Ridge cairns

Cairn Observer Point	Cairn number Engelbach	2012 survey	SPOT	OFFSETA	OFFSETB
COB1	I	03	194	1.28	1.60
COB2	II	02	194	1.28	1.60
COB3	III	N/A	194	1.28	1.60
COB4	IV	N/A	194	1.28	1.60
COB5	V	N/A	194	1.28	1.60
COB6	VI	06	193	1.28	1.60
COB7	VII	011	192	1.19	1.60
COB8	VIII	012	192	1.36	1.60

2.7. Other parameters affecting the visibility analysis

In addition to the specific parameters for the visibility analysis, which were discussed in the previous section, various other factors affect visibility and must therefore be considered during the visibility analysis. These include the curvature of the earth, the refraction of light by particles in the atmosphere and visual acuity. Although some of these factors are constant for all people or all areas of the planet, others vary depending on the specific location and environmental conditions. This section considers these parameters, how they apply to the visibility analysis and what, if anything, can be done to account for them.

2.7.1. Algorithm

Different GIS programmes make use of different algorithms for calculating intervisibility and viewsheds. Research has shown that the different methods used by different GIS programmes can produce different viewsheds from the same data (Fisher 1993; Israelevitz 2003).

To assess the differences between viewsheds of Stelae Ridge produced by different GIS programmes projective and reflective viewsheds of OB8, in the court of cairn VIII, were generated in ArcGIS 10.1 and in GRASS GIS 7.0. The viewshed generated in ArcGIS 10.1 used the 'Viewshed' tool of the 'Visibility toolset' of the '3d Analyst' toolbox.[136] The viewshed generated in GRASS used the r.viewshed function.[137] Other than the GIS programme, and therefore the algorithm used, all other parameters were kept the same. The viewsheds were generated from the SRTM for an observer of 1.6m and a target of 0m. Ground level was taken from the SRTM in both cases and there was no correction for the curvature of the earth and the refraction of light. The sizes of the viewsheds were determined using the method described in section 2.4.4.

Fig 2.6 shows the viewsheds generated by ArcGIS 10.1 and GRASS 7.0. Table 2.7 provides the sizes of the viewsheds generated by both programmes in km^2. The results show that the viewsheds created by GRASS using r.viewshed are larger than those created by ArcGIS. Both the projective and the reflective viewsheds created by GRASS are larger than the equivalent viewsheds created by ArcGIS. The GRASS reflective viewshed is very much larger, being over twice the area of the ArcGIS reflective viewshed.

---

[136] http://resources.arcgis.com/en/help/main/10.1/index.html#//00q900000033000000, last accessed 11 March 2015.
[137] http://grass.osgeo.org/grass70/manuals/r.viewshed.html, last accessed 11 March 2015.

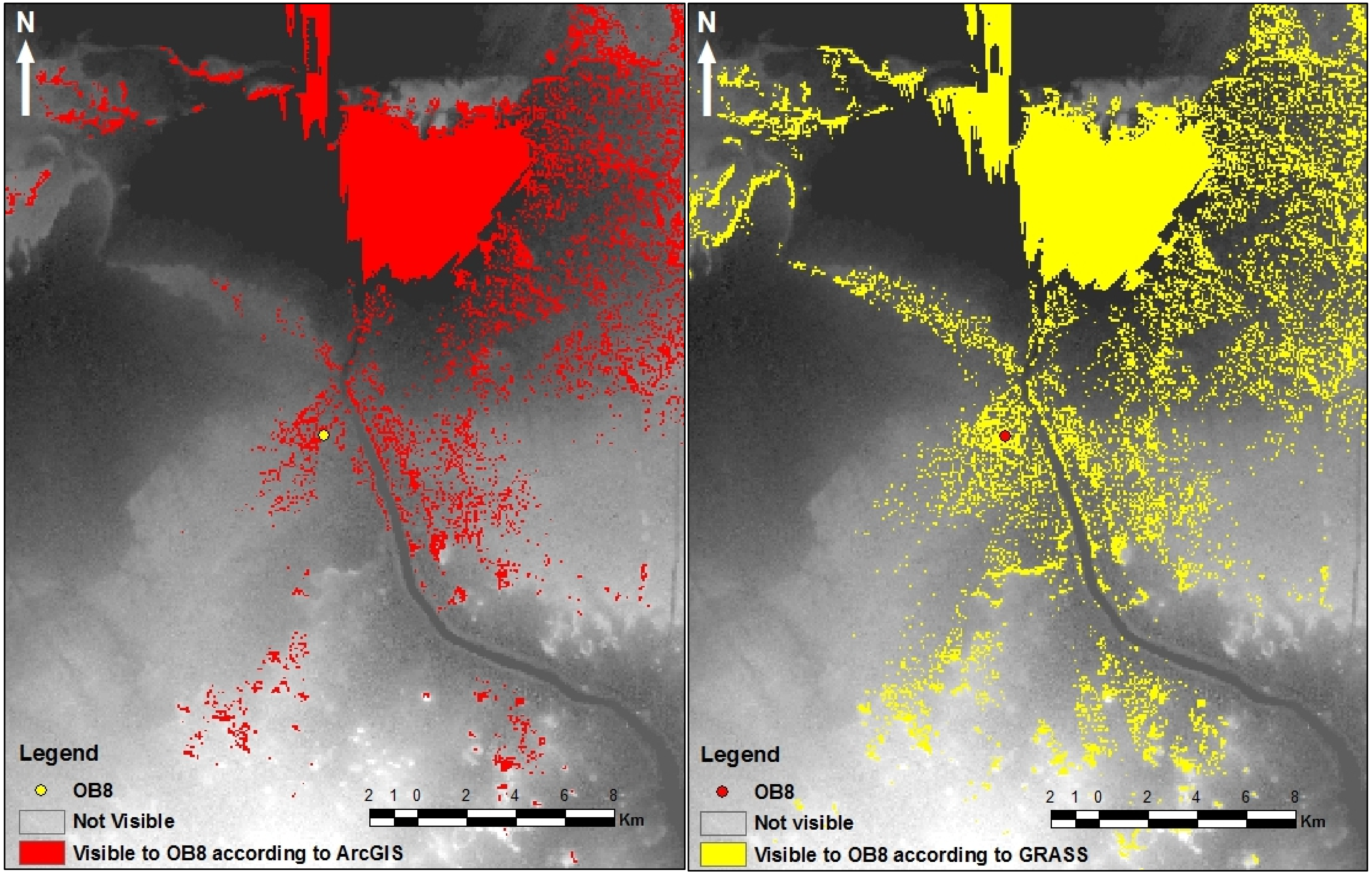


Fig 2.6a: Comparison of the projective viewsheds for OB8 created using a) ArcGIS 10.1 (left) and b) GRASS 7 (right). Coloured areas show what is visible from OB8 according to each GIS programme and are presented overlying the SRTM tile (SRTM data available from USGS).

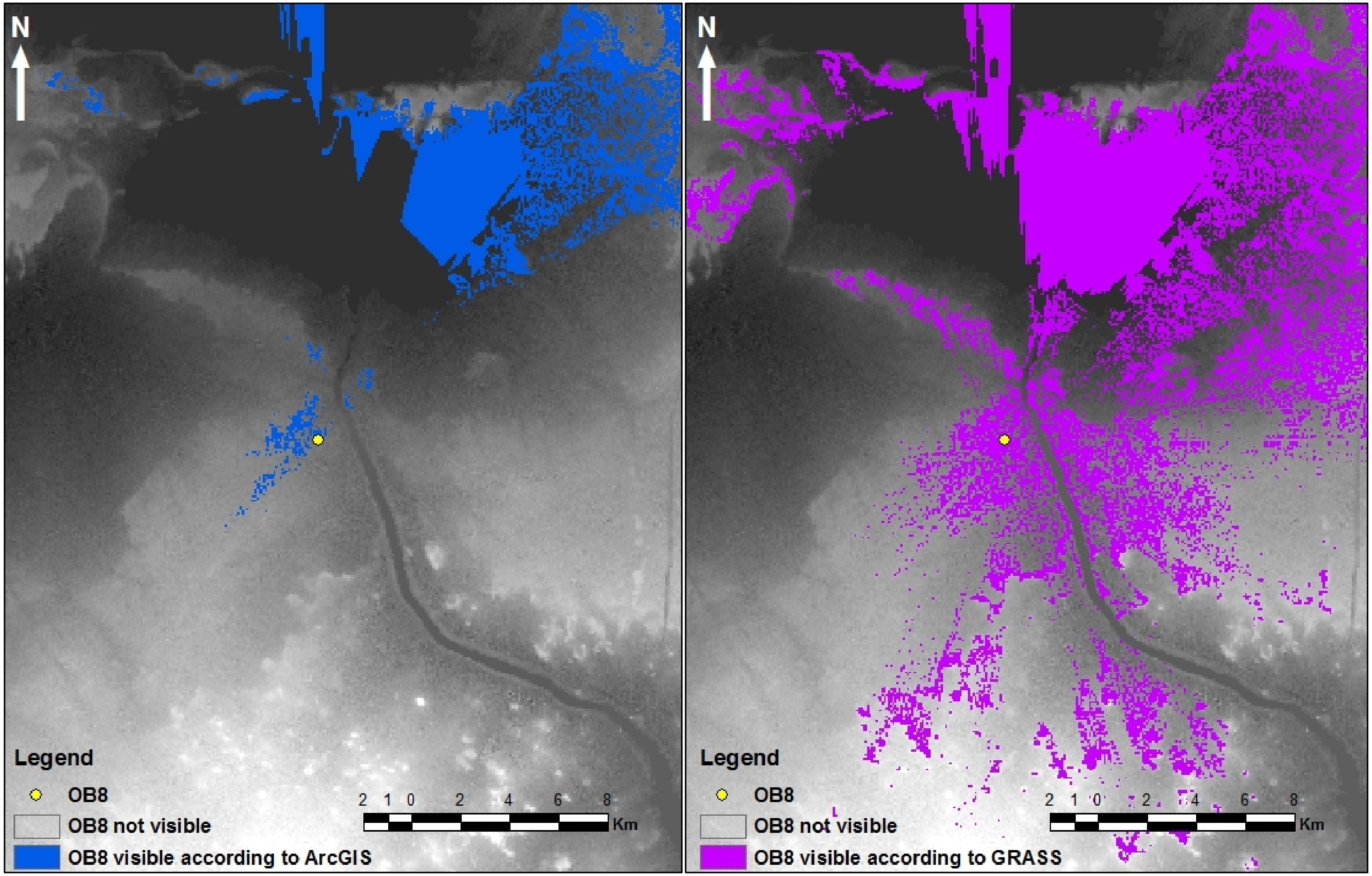


Fig 2.6b: Comparison of the reflective viewsheds for OB8 created using a) ArcGIS 10.1 (left) and b) GRASS 7 (right). Coloured areas show where OB8 is visible according to each GIS programme and are presented overlying the SRTM tile (SRTM data available from USGS).

Table 2.7: Comparison of the sizes of the projective and reflective viewsheds produced by ArcGIS and GRASS for OB8, with 1.6m high observers and without correction for the curvature of the earth and the refraction of light.

	ArcGIS 10.1		GRASS 7.0	
	Number of raster cells	Area (km^2)	Number of raster cells	Area (km^2)
Projective	39871	298.05	53595	400.64
Reflective	31204	233.26	76625	572.80

There are also differences between ArcGIS and GRASS in the areas of landscape included in the viewsheds. As well as being generally larger, the GRASS projective viewshed included areas to the south of Stelae Ridge which ArcGIS did not consider visible to OB8. The GRASS projective viewshed also included a much larger area to the north-west of Stelae Ridge than the ArcGIS viewshed. The greatest difference between the shape of the ArcGIS and GRASS viewsheds is evident in the reflective viewsheds. ArcGIS identified a relatively limited area from which OB8 would be visible, primarily to the north-east and west of Stelae Ridge. The ArcGIS reflective viewshed was thus quite different to the projective viewshed. The GRASS reflective viewshed included a full 360° around the site and, although larger than the projective viewshed, was broadly reciprocal to it in terms of the shape of the viewshed and the areas deemed inter-visible with OB8.

Since all other parameters were kept the same, the differences between the viewsheds produced by ArcGIS and GRASS for OB8 must be the result of the different algorithms used to calculate them. These differences reflect different approaches to modelling visibility in GIS programming and reveal how slight differences in algorithm could potentially change the results and conclusions of a visibility analysis. The detailed method by which GRASS determines visibility using r.viewshed is described in the relevant documentation,[138] but the method used by ArcGIS is only described in general terms.[139] It is therefore difficult to determine precisely how the two programmes produce such different results and which method is better, if any. However, it is worth mentioning that the author's experience of visibility at the site suggested that real visibility is actually somewhat less extensive than the ArcGIS viewsheds imply.[140] In reality, some areas of the landscape that are notionally visible according to ArcGIS are not actually visible to a human observer, particularly in the middle

[138] http://grass.osgeo.org/grass70/manuals/r.viewshed.html, last accessed 16 March 2015.
[139] http://resources.arcgis.com/en/help/main/10.1/index.html#//009z000000v3000000, last accessed 16 March 2015.
[140] The author's experience of visibility at the site is described in Chapter 3, section 3.7.3.

and far distance. Given that even the smaller viewsheds produced by the ArcGIS algorithm are larger than the actual visible areas, the much larger viewsheds suggested by GRASS are likely to be even less realistic.

Because of this, and to ensure that all the viewsheds considered in this research are comparable with each other, ArcGIS 10.1 has been used throughout to produce all the viewsheds for the visibility analysis of Stelae Ridge.

2.7.2. Curvature of the earth

The curvature of the earth and the refraction of light reduce the distance it is possible to see, irrespective of the visual acuity of the observer. ArcGIS 10.1 allows visibility analysis to take account of the curvature of the earth and the refraction of light,[141] but this function was not available when all eight observer points were analysed. As this research required a minimum of eight points, automatic correction for curvature of the earth and the refraction of light was not employed, except where specifically stated and for limited testing of the DEM in Chapter 4, section 4.3.

2.7.3. Visual range

Although it cannot be explicitly corrected for in the analysis, curvature of the earth and refraction of light can be generally considered in the context of visual range. Visual range is the distance it is possible to see and is affected by three components; the curvature of the earth; atmospheric refraction of light; and human visual acuity.

The curvature of the earth has the effect of reducing the elevation of a target by *c.* 7.86m for every 10km distance from the observer (Conolly and Lake 2006, 229). This has a significant impact on the visibility of distant objects depending on how high they are. Atmospheric refraction of light and human visual acuity are more complex.

2.7.4. Atmospheric refraction

The refraction and absorption of light by various particles in the air degrades visibility to a point where objects are no longer visible because of atmospheric extinction.[142] Modelling atmospheric extinction is complicated because of the many different types of particles that can have an impact, but the theoretical maximum possible visual range is 330km at sea level

---

[141] http://resources.arcgis.com/en/help/main/10.1/index.html#//00q900000033000000, last accessed 20 October 2014.

[142] Malm (1999) provides a detailed discussion of the various atmospheric factors affecting modern visual range, based on particle and visibility monitoring programmes in the United States.

(Ogburn 2006, 407). Real maximum visual range is much less and is highly variable, depending upon the height above sea level, climate, weather and human activity in the area, which all affect the number and type of particles in the air.

Research into global variation of the aerosol extinction coefficient (B_{ext}) based upon ground observation of visual range at a number of observation points across the globe recorded data from the Stelae Ridge area of the eastern Sahara, which was identified as a notably hazy region (Husar *et al.* 2000, 5073). The B_{ext} of the area around Stelae Ridge varies from 0.15–0.20km^{-1} around the year.[143] Using Koschmieder's (1926) equation, it is possible to calculate the visual range. Normally, the Koschmieder constant (K) is taken to be 3.912, but in this calculation K= 1.9 will be used for consistency with Husar (*et al.* 2000, 5068). Using 1.9 as the Koschmieder constant, visual range in the Stelae Ridge area can be calculated from the coefficient of extinction as 9.5–12.67km.

This visual range reflects modern data and it is likely that prior to modern pollution the visual range was higher in the area of Stelae Ridge. A more hospitable climate might also have slightly increased visual range, but it is not likely to have been that much higher because the climate was only slightly more hospitable.[144]

2.7.5. Visual acuity

The visual acuity of the observer would inevitably influence the visibility of topographic and cultural features within a given landscape. Modern studies classify and measure visual acuity in various ways. Ogburn (2006, 406) identifies three of the five[145] commonly measured forms of visual acuity as most relevant to visibility within a landscape. Recognition acuity, the 'ability to recognise and identify a target stimulus (Ogburn 2006, 406)' is probably the most important. Studies have determined that, for modern people with good vision under good conditions, the threshold for recognition acuity and resolution acuity is a target that subtends, or occupies, 30" of the visual arc of the observer. The maximum threshold for detection acuity is 0.5" of visual arc (Ogburn 2006, 406) confirming that the threshold for detection acuity is less than the thresholds for resolution and recognition acuity.

Ogburn (2006, table1) has calculated the distances over which objects of different sizes would be visible, based on the thresholds for recognition acuity described as the amount of

---

[143] This information is contained within Husar *et al.* (2000, Fig 3) and is also available online in a preliminary version of the report accessed 25 March 2014 at http://capita.wustl.edu/CAPITA/CapitaReports/GLOBVIZ/GLOBVIS1.html.
[144] See Chapter 4, section 4.4 for discussion of the climate at Stelae Ridge in the Middle Kingdom.
[145] Schiffmann (2001)

the visual arc the object subtends. According to this table, an object of 1m diameter is recognisable at a maximum distance of 6880m, based on a recognition acuity of 30” of visible arc. For people with normal vision,[146] where the threshold for recognition acuity is defined as 1’ of visual arc, this distance is 3440m for an object of 1m.

Ogburn calculates that larger objects would be recognisable at longer distances. All the Stelae Ridge cairns are at least 5m in diameter and smaller than 10m in diameter. Based on the table given by Ogburn (2006, table1) they would be visible at a distance of 17,200m but would have ceased to be visible at 34,400m for those with ‘normal’ vision. The maximum distance over which they would be visible, for those with better than normal vision, would be at least 34,400 but less than 68,800m.

However, these figures are purely mathematical constructs based on modern populations. There is also an individual element to visual acuity. It is likely that some proportion of ancient populations would have had less than ‘normal’ sight, but it is impossible to know the proportion or distribution of these individuals within the ancient population in general, or within a specific society in particular. The distances detailed above, can therefore be considered to be theoretical maximums that might be practically reduced by individual physiology.

Ogburn’s theoretical distances would also have been reduced by the curvature of the earth and atmospheric refraction. Assuming Ogburn’s 10m diameter object was also 10m high, the curvature of the earth would give it an effective height of minus 1.79m to a viewer only 15km away,[147] rendering it invisible long before the theoretical maximum distance of 34,400m or greater. This is not absolutely accurate in practice, because the surface of the earth exhibits topographic relief and observers are rarely at precisely the same height as their targets, but maximum visual range would be more limited than Ogburn’s calculations suggest.

If the visual range from atmospheric extinction at Stelae Ridge in the Middle Kingdom is taken to be 9.5–12.67km, or slightly more, the 10m diameter object would cease to be visible before it disappeared below the horizon. Allowing for lower levels of pollution and the effects of a slightly more hospitable climate in the Middle Kingdom, a maximum figure of 15km would seem reasonable. Although the hypothetical 10m diameter object would not be visible

---

[146] That is 20/20 or 6/6 eyesight, which is defined as ‘normal’ vision in modern optometry.
[147] Based on a reduction of *c.* 7.86m in perceived target height for every 10km distance from the observer (Conolly and Lake 2006, 229).

over this distance due to the curvature of the earth, larger topographic features would still appear.

A maximum visual range of 15km is also supported by the author's experience of visibility and visual range at Stelae Ridge in 2012.[148] Photographic panoramas and a circular view indicated that the Gebel el-Asr would be visible from Stelae Ridge under normal or good conditions, while 20 cairn hill would be visible in all but the worst conditions. The Gebel el-Asr is 11.5km and 20 cairn hill is 5.8km from Stelae Ridge. Some gebels to the south of Gebel el-Asr were visible under the very good conditions experienced at the site in 2012. These were difficult to identify, but there are a group of such features *c.* 2–3km south of Gebel el-Asr. Only the highest and most prominent of these gebels are likely to be visible from Stelae Ridge, and then only under the best conditions. Under such circumstances maximum visual range would be *c.* 11.5km plus 2–3km, or *c.* 15km at most.

2.7.6. Modelling visual acuity in the GIS

Various authors have made attempts to model the variability of visual range in a GIS environment.[149] Ogburn's (2006, 409) adaptation of Fisher's (1994) fuzzy viewshed formula provides a useful method of assessing the likely visibility of objects of known size as distance from the target increases. However, more complex GIS techniques are not necessarily beneficial to answering archaeological questions.[150] While there is an elegance to Ogburn's modified fuzzy viewsheds, they still have hard numerical limits to the different colours or shades and are arguably insufficiently 'fuzzy' to express the gradual degradation of vision over distance. The addition of the different shades required to express Ogburn's modified fuzzy viewsheds also adds another layer of complexity that could be highly confusing where the various colours of a cumulative viewshed are presented or where multiple viewsheds are shown on the same image. The use of Ogburn's modified fuzzy viewsheds has therefore been avoided both in the interests of clarity and because it was felt unnecessary to the research. This research is not primarily concerned with binary questions of what could be seen from Stelae Ridge or where it could be seen from, or with depicting the experience of visibility. Instead, the viewsheds provide data concerning the patterns of visibility amongst the Stelae Ridge cairn-courts, which reveal new information about the

[148] The author's experiences are discussed in Chapter 3, section 3.7.3.
[149] See Wheatley and Gillings (2000) for an approach to modelling the decay in visibility using Tadahiko Higuchi's (1983) visual index of distance and Fisher (1994) for an approach using fuzzy set theory. Felleman (1986) offers another approach. Ogburn (2006, 408) discusses these approaches and makes relevant criticisms in his adaptations of Fisher's fuzzy viewsheds.
[150] See the arguments in Gillings (2009).

structures, their relationship with the wider landscape and the intentions behind their construction.

While more complex forms of depicting variable visibility have been avoided, the 15km maximum visual range has been taken into account and is regularly shown on the viewsheds. Where the sizes of viewsheds have been quantified, their size is only considered within 15km of Stelae Ridge.

Furthermore, figures depicting viewsheds, particularly in Chapter 6, also divide the viewsheds into areas that can be seen from a given point or points, areas where those points are visible and areas which are both visible to and afford a view of those points. The interplay of these different colours within the viewsheds provides some indication of the differences between the 'core' viewshed, where visibility is reciprocal and areas are both visible to and afford views of the point or points; and more peripheral parts of the viewshed which do not exhibit reciprocity and are either visible to the points *or* afford views of them.

In addition the author's experience of visibility at the site,[151] including the author's experience of the degradation of visibility and visual range, has been taken into consideration in discussions of the results of the visibility analysis. While the author's experiences are likely to be different from the experiences of Middle Kingdom individuals at the site, they represent another piece of evidence and context for the visibility analysis.

2.8. Conclusion

This research draws upon current approaches in archaeological theory and GIS research, which emphasise the need for GIS research to be theoretically founded, responsive to criticism and answer genuine archaeological questions.[152] While innovation offers the prospect of new technological approaches, this author agrees with Gillings (2009) that the understandable desire for improved technology can obscure the possibilities offered by existing GIS. In this case established types of visibility analysis, available within commercial GIS software, provide suitable tools for systematically interrogating the visibility of the Stelae Ridge cairn-courts to develop new evidence toward their re-interpretation. This re-interpretation is not based upon the visibility analysis alone, but considers the evidence of visibility in the context of the archaeological and textual remains from the site and the wider cultural context. The theoretical foundation for this research is therefore modern hermeneutic

[151] The author's experience of visibility at the site is documented in Chapter 3 section 3.7.3.
[152] For criticisms of GIS and responses to them, see discussion and references in Chapter 1, section 1.3.2.

contextual archaeology,[153] within which the GIS visibility analysis is an analytical tool that contributes evidence for interpretation.

Since it functions as an analytical tool, the goals of the GIS visibility analyses were not just binary questions of what could be seen from Stelae Ridge or from where it could be seen. Instead the GIS tools were used to investigate systematically the visibility of the structures on Stelae Ridge and identify similarities and differences between the visibilities of individual structures and groups of them, revealing their different visual properties.[154]

The visual properties of the Stelae Ridge structures, identified during the systematic visibility analysis, were compared, analysed and interpreted in Chapter 6 in the light of evidence from archaeological remains and inscriptions from the site, and in view of the Middle Kingdom cultural context. The process of interpretation included comparison of relevant viewsheds with the archaeological and topographic features in the landscape around Stelae Ridge, investigated during the preliminary research and presented in Chapter 3, section 3.3 and 3.6. Where appropriate, additional visibility analyses were undertaken so that the visibility afforded by Stelae Ridge could be compared to the visibility afforded by other ridges in the vicinity. The interpretations, comparisons and new visibility analysis relied upon the evidence collected, georeferenced and analysed during the preliminary research and presented in Chapters 3 and 4, but the direction of the research was suggested by the results of the systematic visibility analysis of the Stelae Ridge cairn-courts, presented in Chapter 5. Thus the integration of multiple sources of evidence, including systematic GIS-based visibility analysis, provided new directions for research into the Stelae Ridge structures and ultimately new interpretations of them.

[153] For hermeneutic and contextual archaeology see the discussion and references in Chapter 1, section 1.3.2.
[154] For the methods used in the systematic visibility analysis see section 2.4 and section 2.5. For the results see Chapter 5.

3. The archaeological remains at Stelae Ridge

This chapter considers the evidence for the location and layout of the archaeological remains at Stelae Ridge. It includes published and unpublished data from past excavation and survey, evidence obtained from satellite imagery and research undertaken at the site in 2012 specifically for this project. The analysis of this evidence provides the foundation for the subsequent visibility analysis and interpretation.

A thorough understanding of the archaeological remains and their context is important for any interpretation, while their precise geographic location and layout suggest the most appropriate observer locations for both the systematic visibility analysis of the eight Stelae Ridge cairn-courts and subsequent visibility analysis of any other relevant locations.

[155] In this particular case, analysis of the various sources of evidence is even more imperative because recent developments have significantly altered the surviving archaeological remains and make it difficult to relate the extant remains to the limited historic excavation records.[156]

3.1. Discovery and excavation

Stelae Ridge is located within the Gebel el-Asr gneiss quarries, which were rediscovered in 1932 by a British Military car patrol vehicle that strayed from its intended route during a sandstorm and investigated two cairns, discovering stelae of Djedefre and Amenemhat II in the process (Engelbach 1933, 66).

Two archaeological expeditions travelled to the site in 1933 (Engelbach 1933) and 1938 (Engelbach 1939; Murray 1939). They recorded the archaeological remains at Gebel el-Asr and Stelae Ridge, undertook some small excavations and removed inscribed artefacts to the Cairo museum. The first of these expeditions, in 1933, identified a series of ancient cairns at Stelae Ridge, recovering the Middle Kingdom stelae that have given the location its modern name (Engelbach 1939, 370).

---

[155] For the observer points for the systematic visibility analysis of the eight Stelae Ridge cairn-courts see Chapter 2, section 2.5. For the visibility analysis of other selected locations around Stelae Ridge and within the Gebel el-Asr gneiss quarries, see Chapter 6, section 6.1 and 6.5.

[156] For the effect of recent development projects upon the archaeological remains at Stelae Ridge and elsewhere at Gebel el-Asr see the summary in Shaw *et al.* (2010, 302–303) and Storemyr (2009, 114).

A geological survey of the Gebel el-Asr region was undertaken in 1990 (Harrell and Brown 1994) and between 1997 and 2004 the Gebel el-Asr Project[157] investigated the remains at Stelae Ridge. At Stelae Ridge, the Gebel el-Asr project recovered a stela of Amenemhat II (Shaw *et al.* 2001, 34), identified carnelian as the main product of the mines and confirmed that most of the surface pottery around Stelae Ridge was Middle Kingdom (Shaw 2000a), although one Old Kingdom sherd was found (Shaw 2003). Unfortunately the Gebel el-Asr Project also recorded that the Stelae Ridge cairns had been badly damaged by construction of the nearby Sadat canal spillway and Gebel Uweinat road (Shaw *et al.* 2010, 302–3; Storemyr 2009, 114).

The most significant element of the Gebel el-Asr Project for this research was the survey of the quarrying area undertaken using a differential Global Positioning System (GPS). This survey produced a geo-referenced database of archaeological sites (Bloxam 2003b, 36–37; Shaw and Heldal 2003; Shaw *et al.* 2010, 295), with geographical coordinates accurate to 5m (Bloxam 2003b, 37) that can be imported directly into the GIS.

The published record, plans and Gebel el-Asr Project survey data, provide evidence of the archaeological context of the site. Translations of the texts from the site by Rowe (1939) and Darnell and Manassa (2006; 2013) provide additional context, and textual parallels with other mining and quarrying sites.[158] Based on the archaeological and epigraphic evidence from the site, and relevant comparable material, the eight cairns at Stelae Ridge have been interpreted by Darnell and Manassa (2013) and the author (Pethen 2006; 2014) as ritual structures for the worship of local divinities, specifically a local form of the goddess Hathor, and the Pharaoh.[159] This function is understood in terms of the Egyptian perception that the desert was a numinous location, which produced minerals, stones and gemstones imbued with divine power.[160] The inscriptions also suggest an additional function as commemorative

---

[157] See Shaw *et al*. (2010) for an overview of the project results to date.
[158] Other Middle Kingdom mining sites with similar evidence include Serabit el-Khadim (Černy *et al.* 1955; Petrie 1906, 65–69; Valbelle and Bonnet 1996); Gebel el-Zeit (Castel and Soukiassian 1985a; Régen and Soukiassian 2008); Wadi el-Hudi (Fakhry 1952; Sadek 1980; Shaw 1998) and the Wadi Hammamat (Lloyd 2013). There are also parallels with the 12th Dynasty cairns and stone circles at the harbour of Mersa Gawasis, at the end of the route through the Wadi Hammamat (Bard *et al.* 2013).
[159] An interpretation of Stelae Ridge and similar centres of Hathor worship linked to creating trust between Egyptian purchasers and local purveyors of the precious minerals (Bloxam 2006) has been discussed in Chapter 1 section 1.2.2 together with other interpretations. It is broadly consistent with the interpretations advanced by Darnell and Manassa and the author, but only if some Egyptian presence at Stelae Ridge is posited to account for the Egyptian-style layout and apparent reading ability of the cairns' builders.
[160] For the numinous nature of the desert and the power ascribed to its mineral deposits see Aufrère (1983; 1991; 1997; 2001). Similar ideas are also present in inscription WH143 (Sadek 1980, 84) and inscriptions from the Wadi Hammamat (Lloyd 2013). Valbelle and Bonnet (1996, 120–125) accept the

structures for members of the expedition.[161] These interpretations are reasonable as far as the archaeological and textual evidence is concerned, but they do not take account of the site's location or landscape context, which may enrich them or suggest additional possibilities.

3.2. The archaeological context of the Stelae Ridge structures

The publications of the site by Engelbach (1933; 1939) provide details of the archaeological context of the structures at Stelae Ridge, including the layout of the eight cairn-courts, and the locations of the inscribed artefacts (Fig 3.1). Rowe (1939) and Darnell and Manassa (2006; 2013) provide details of the inscriptions on those artefacts.

3.2.1. Sketch plan of the Stelae Ridge cairn-courts

The only map to provide a plan of arrangement of the structures and artefacts at Stelae Ridge, is Engelbach's sketch plan (Fig 3.1). It shows the eight cairns divided between two ridges. Cairns VI, VII and VIII are arranged in a north-south line on the northern ridge, hereafter referred to as 'Stelae Ridge north'. Cairns I-V are located on the southern ridge, 'Stelae Ridge south', aligned roughly north-west to south-east following the line of the ridge. All but one of the cairns (Cairn III) have flat eastern sides. Traces of courts, outlined in stones, are shown on the eastern sides of five cairns (Cairns II and V-VIII).[162] Most artefacts were located within the courts or on the eastern sides of cairns. A few artefacts were located elsewhere, perhaps due to historic disturbance.[163]

---

numinous nature of the desert and its mineral deposits, although they do not agree with all of Aufrère's conclusions with regard to Serabit el-Khadim.

161 This is common to many mining and quarrying inscriptions, including those discussed in the previous footnote and others (Blumenthal 1977; Eichler 1994; Seyfried 1982); and also has parallels at religious and funerary sites in the Nile valley (Franke 1994; Habachi *et al.* 1985; O'Connor 1985; Richards 2005, 38–45; Simpson 1974; 1980).

162 Variation in the structure of the features is discussed in section 3.2.4 with regard to the three cairns without dry-stone courts and the one round cairn.

163 Engelbach (1933, 68) suggested that they had been disturbed by the Romans who left small amounts of Roman pottery, which were also found by the Gebel el-Asr Project (Shaw 2000a, 30).

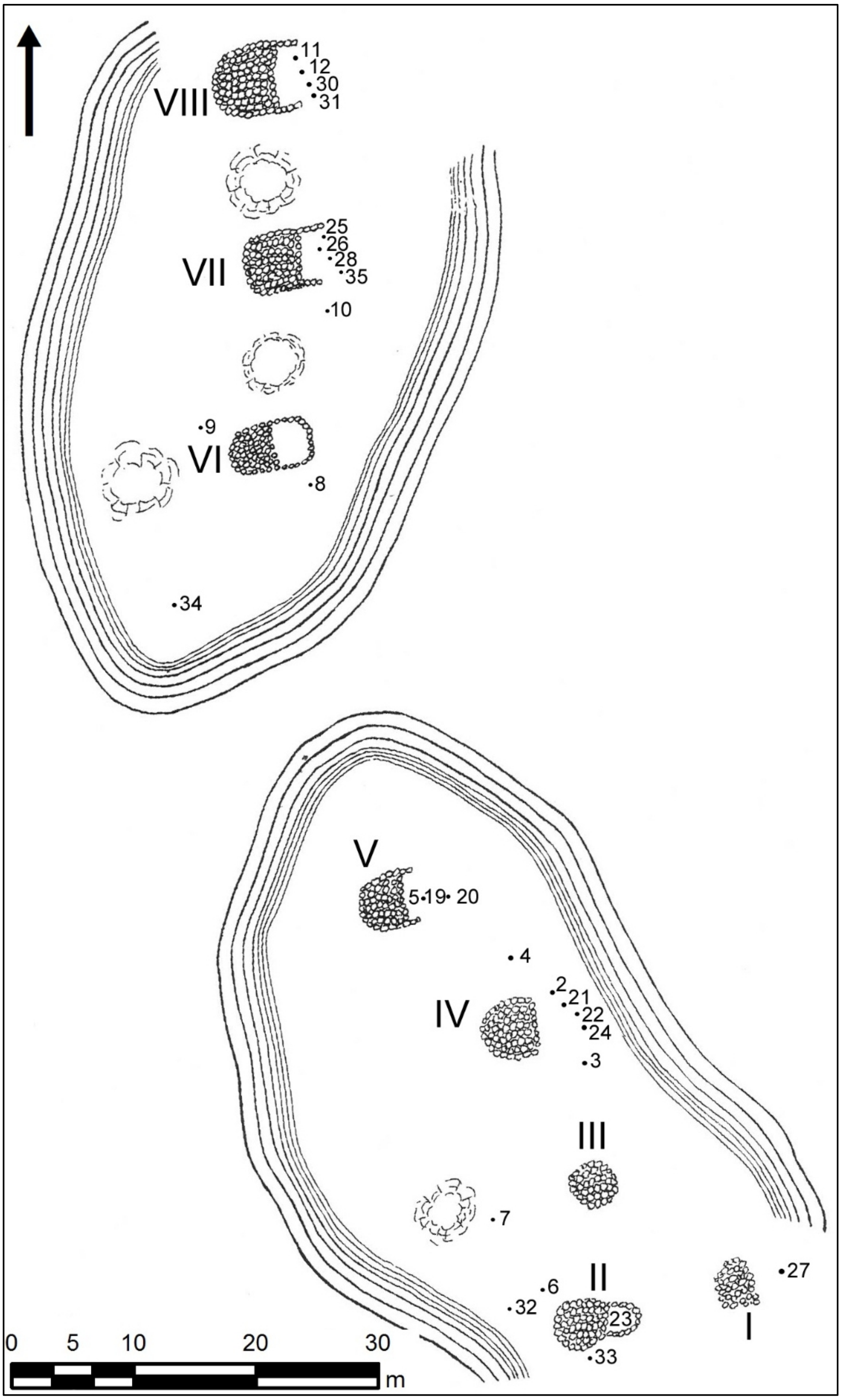


Fig 3.1: Engelbach’s sketch plan of the Stelae Ridge cairns. The cairns are numbered by Roman numerals and the finds by smaller Arabic numerals. Arrow indicates north. (Modified from an original in Engelbach 1939, pl. LIV).

Table 3.1: Artefacts recorded by Engelbach. 'Artefact no' corresponds to the small Arabic numbers shown on Fig 3.1.

Cairn	Artefact No.	Museum No	Object	Pharaoh	Year	Script	Dimensions (cm)
I	1	JE59497	Falcon	Amenemhat III	N/A	Hieroglyphic	Unknown
I	27	JE59495	Stela	Amenemhat III	4	Unknown	40.5x21.5
II	6	JE59506	Stela	Amenemhat III?	13	Hieroglyphic	48x36
II	23	JE59490	Stela	None	None	Semi-hieratic	47.7x16.5
II	33	N/A	Unknown	Unknown	Unknown	Unknown	Unknown
II	32	N/A	Unknown	Unknown	Unknown	Unknown	Unknown
IV	2	JE59504	Stela	Senusret I	20	Hieroglyphic	55.5x42.4
IV	24	JE59492	Stela	None	None	Hieroglyphic	34.5x23.5
IV	3	JE59496	Stela	None	None	Hieroglyphic	51x32
IV	4	JE59505	Stela	Amenemhat I and Senusret I	Unknown	Unknown	61x43.5
IV	21	JE59502	Stela	None	None	Lapidary hieratic	20.2x18.5
IV	22	JE59486	Stela	None	None	Unknown	24.5x16
N/A	7	15.4.33.6	Offering table	Unknown	Unknown	Unknown	Unknown
V	5	JE59507	Stela	Unknown	Unknown	Unknown	48.5x30
V	20	JE59493	Stela	None	None	Unknown	25.5x18.5
V	19	15.4.33.5	Stela	Unknown	Unknown	Unknown	Unknown
VI	9	JE59485	Stela	Senusret II	8	Hieroglyphic	47x28x11.5
VI	8	JE59498	Falcon	Senusret II	None	Hieroglyphic	Unknown
VI	34	N/A	Unknown	Unknown	Unknown	Unknown	Unknown
VII	26	15.4.33.1	Falcon	Unknown	None	None	Unknown
VII	28	JE59500	Stela	Amenemhat III	Unknown	Hieroglyphic-Hieratic	20.7x26.5
VII	25	JE59501	Stela	None	None	Semi-hieratic	20.7x11
VII	10	15.4.33.7	Offering table	Unknown	Unknown	Unknown	45x25
VII	35	N/A	Unknown	Unknown	Unknown	Unknown	Unknown
VIII	12	JE59488	Stela	Amenemhat III	6	Hieroglyphic	59.5x34x9
VIII	11	JE59499	Stela	Amenemhat III	4	Lapidary hieratic	47x38
VIII	31	JE59484	Stela	Amenemhat III	4	Hieratic	23.5x25.5
VIII	30	JE59503	Offering table	None	None	Hieroglyphic	27.3x27.5

3.2.2. Artefacts shown on the sketch plan

The sketch plan shows a number of artefacts, recorded as points with small Arabic numerals. The artefacts referred to by these numbers are listed by Engelbach cairn number in Table 3.1, which has been created using Engelbach's (1939, 387 and pl. LIV) records, the publication of four artefacts from court VIII (Darnell and Manassa 2013), and unpublished translations of the inscriptions on the other artefacts (Darnell and Manassa, 2006). In the table Pharaoh, year, script and dimensions are listed as 'unknown' if the object was too badly damaged for the researchers to know. Although Engelbach numbered the cairns, the artefacts were mostly found in the adjacent courts, which are described by the same number as their respective cairns.

The table shows that courts I, VII and VIII were all associated with falcon statues.[164] Court VII and VIII both produced offering tables and a third offering table was found some distance west of cairn III, although not associated with it. Court IV contained a stela dating to the co-regency of Amenemhat I and Senusret I and one from the sole reign of Senusret I,[165] court VI was associated with artefacts of Senusret II. Courts I, VII and VIII all contained stelae of Amenemhat III. Cairn-court II is also associated with a stela of year 13 of an unnamed Pharaoh, which Darnell and Manassa (2006) suggest should be attributed to Amenemhat III.

There does not appear to be any correlation between the ridges on which the cairns are located and their dates or the types of artefacts found at them. Cairns of Amenemhat III were found on both ridges. Falcon statues and offering tables were found on both ridges, but were not present at every cairn. Stelae Ridge south is the only ridge to have a round cairn (Cairn III) and cairns without courts (Cairn I and IV), but cairns II and V on the same ridge both have flat eastern faces and courts.

3.2.3. Dating and chronology of the cairn-courts

Although it is impossible to be certain in the absence of any dating evidence from the structure of the cairns, it seems likely that each was constructed to house the artefacts associated with it. Most of the artefacts appear to be *in situ*. In most cases they are located, typically in a line, along the eastern face of the cairns. Artefacts numbered 6, 7, 8, 9, 10, 32,

---

164 For the falcon statues at this and other mining sites see Pethen (2014).
165 For co-regency in Egypt in general see Murnane (1977); Tanner (1974); Uphill (2001). For the co-regency of Amenemhat I and Senusret I see Helck (1989) and Simpson (1956).

33, and 34 are located outside the courts and away from the eastern side of the cairns and were probably moved in antiquity.[166]

If and when artefacts were moved, it is unlikely that they were moved far from their original cairn-court. The artefacts at Stelae Ridge were spread across the two ridges. At court VIII, with the best combination of textual and archaeological preservation, the arrangement of three stelae and an offering table suggest an attempt to create a simple offering place.[167] Where stelae and other artefacts are reorganised in ritual contexts they are usually all grouped in one place without any attempt to retain original arrangements such the offering place present at court VIII.[168]

Factors which might lead to a reorganisation of the artefacts, such as a desire to allow one cairn for each pharaoh or expedition, do not appear to be present. Artefacts recording Amenemhat III have been found at multiple cairn-courts, including structures at opposite ends of the ridge. No one cairn-court housed artefacts dating to more than one reign, since the conjunction of Amenemhat I and Senusret I on the same stela in court IV is due to their co-regency. While there may have been some limited reorganisation, resulting in stelae of year 4 and year 6 of Amenemhat III at cairn VIII, this is explicable by their relationship with the seal-bearer Sabastet.[169] It seems unlikely that large numbers of artefacts were moved a long way from their original cairns. There is no evidence of substantial reorganisation or re-deposition of used stelae in Egyptian-style ‘deposits’.[170] Later, post-Pharaonic visitors would probably not have been sufficiently interested to move the stelae very far from their original positions.

It is possible that the structures predate the artefacts and this would have an impact upon the visibility analysis. If the cairns had been constructed earlier and re-used, we might expect some to have no artefacts. Yet the only cairn without any artefacts around it is cairn III, which is markedly different from the others. All the dated artefacts are 12th Dynasty and

---

[166] Given the long period of use from at least the co-regency of Amenemhat I and Senusret I to the reign of Amenemhat III and the thousands of years of abandonment since, some movement might be expected, particularly as there is evidence of a Roman presence at the site (Engelbach 1933, 68; Shaw 2003, 453).
[167] See Darnell and Manassa (2013, 89–92) for cairn-court VIII as an offering place and comparisons with similar constructions elsewhere.
[168] See for example the deposit of stelae from the galena mining site at Gebel el-Zeit (Castel and Soukiassian 1985a; Pinch 1993, 72; Régen and Soukiassian 2008), and the arrangement and rearrangement of stelae in the Hathor temple at Serabit el-Khadim (Valbelle and Bonnet 1996; 101–112). For the grouping of votive objects during other periods of Egyptian history see Van Haarlem (1995; 1996; 2003; 2009) for material from Tell Ibrahim Awad; Dreyer (1986) for material from Elephantine; and various examples in Pinch (1993) and Bussmann (2010).
[169] See Darnell and Manassa (2013).
[170] See the footnote 168 for examples of Egyptian ritual deposits, including examples at mining sites.

almost all the pottery at the site was Middle Kingdom. If some cairns had been constructed much earlier we might expect a significant proportion of earlier pottery, but only one Old Kingdom sherd was recovered (Shaw 2003, 453).

It is therefore unlikely that the cairn-courts are significantly older than the artefacts within or associated with them. Even if some were older, given that most of the artefacts do not appear to have been moved since the Middle Kingdom, the association between the *in situ* artefacts and the cairn-courts comprises a model created by individuals during the Middle Kingdom, even if it was not the first location for each stela or the first use of each cairn. It is therefore reasonable to consider the layout of the archaeological remains as found.

3.2.4. The layout and foci of the structures

Taken as a group, the cairn-court structures appear generally consistent in both construction and layout. Apart from cairn III, they all have a flat eastern side and, apart from cairns I and IV, this eastern side is enhanced by the remains of a semi-circular court outlined in stones. Cairns I and IV may originally have had courts that were removed or, more probably, their intended courts were not constructed due to other constraints. While the courts are not outlined, the layout of the artefacts against the flat eastern face of cairns I and IV, suggests this ‘pseudo-court’ served the same function as more fully constructed courts at other cairns. The similarity of design and layout, indicates that the seven cairns with courts or pseudo-courts had a similar purpose, probably of a ritual nature based upon current interpretations of the site.

Activities probably took place in the courts adjacent to the flat eastern side of the cairns. The juxtaposition of the flat side of the cairns and the court suggests that both components of the structure were constructed together, probably to house the artefacts, which in most cases were found aligned along the flat side of the cairn in the courts and had probably not been moved since their deposition in the Middle Kingdom. It is likely that those artefacts not recovered in the courts had been moved from them in antiquity, but probably not very far. Overall the general pattern suggests that the courts, or pseudo-courts, formed the focal point where the artefacts were arranged and activities took place.

Cairn III is the only unusual cairn, as it is round, has no court on its eastern side and was not associated with any artefacts. All these factors suggest that cairn III may have had a different purpose from the others. Round cairns similar to cairn III occur widely at many sites, including Gebel el-Asr (Engelbach 1939), Gebel el-Zeit (Castel and Soukiassian 1989, 51–54), Wadi el-Hudi (Shaw and Jameson 1993) and Hatnub (Shaw 2010, 97–105; 2013).

Cairns are known to have been used as navigational landmarks (*alamat*) at various sites from the Old Kingdom onwards. The round cairns along the route from the Nile to Gebel el-Asr undoubtedly functioned as landmarks (Engelbach 1939, 388; Shaw and Bloxam 1999, 16). In the Kharga oasis cairns are associated with significant places where desert routes divide (Rossi and Ikram 2013, 270), and cairns also feature amongst the *alamat* along the Abu Ballas trail (Riemer 2013).

A similar function seems possible for cairn III. Stelae Ridge is a local high point in the landscape, similar to those which attract such landmarks, and is close to the carnelian mining area. Prior to the construction of the remaining seven cairns on the ridge, there would have been little to mark it out or identify it and the nearby mine. Cairn III may therefore have been constructed prior to the other cairns to identify the mining area to those travelling to it, but this requires further investigation.

3.3. Engelbach's maps of Gebel el-Asr

While Engelbach's (1939) sketch plan provides the best record of the layout of the structures on Stelae Ridge prior to modern disturbance, it is only a sketch and does not show the outlying archaeological features or peripheral cairns.[171] The geographic location of the Stelae Ridge cairn-courts and other archaeological and topographic sites in the area needs to be understood in order to undertake and contextualise the visibility analysis. In particular, Engelbach's sketch plan of the Stelae Ridge structures and his other maps need to be georeferenced so they are projected to the UTM 36N coordinate system and appear in the correct location in the GIS.[172]

Engelbach (1939) provides two additional plans of Stelae Ridge and other archaeological sites in the Gebel el-Asr region:

- A map of the Gebel el-Asr region, based on the 1:500,000 scale Survey of Egypt map, but with more details of the archaeological remains (Fig 3.2)
- A 1:100,000 scale sketch map of the Gebel el-Asr quarries (Fig 3.3)

[171] Peripheral and outlying cairns are mentioned by Engelbach (1939, 387) and some artefacts were removed from them, but their location was not included in the maps.
[172] For the UTM 36N coordinate system see Chapter 2, section 2.3.1. For the georeferencing Engelbach's maps see section 3.9.

3.3.1. Small scale map of the Gebel el-Asr region

Engelbach’s 1:500,000 scale map (Fig 3.2) of the Gebel el-Asr region shows the general location of the site in relation to nearby routes and the Nile, prior to the creation of Lake Nasser. The Gebel el-Asr region is located north and west of the Nile at Tushka. Stelae Ridge is located to the north of the Gebel el-Asr gneiss quarries, which are centred on the main Middle Kingdom gneiss quarrying area at ‘Quartz Ridge’[173] and ‘Khufu cairn’, where a stela of the Old Kingdom Pharaoh Khufu was found. The Middle Kingdom route between the Nile and the quarries is marked, including the halfway cairn. After the halfway cairn the projected route splits. The northern path turns towards a locality described as ‘20 cairn ridge’ and Stelae Ridge, and the southern aims for the Khufu Stela cairn and Quartz Ridge. The Edfu to Wadi Halfa car route is shown to the east of the site, running along the approximate line of the modern road between Aswan and Abu Simbel. The approximate line of the Darb el-Arba’in desert route from Dunqul oasis to Nakhlai oasis is shown as a dashed line running south-west to north-east to the west of the site, with Nakhlai oasis off the map to the left.

3.3.2. Map of the Gebel el-Asr quarries

Engelbach’s 1:100,000 scale sketch plan of the Gebel el-Asr quarries (Fig 3.3) shows the various archaeological and topographic locations in the area between Stelae Ridge in the north and Khufu Stela in the gneiss quarries to the south-west. In the quarrying area, several quarries and loading ramps are shown at the end of the ‘approximate route to the Nile’. To the north, quarried outcrops, huts and a cairn are shown at Quartz Ridge. An intermediate cairn and the findspot of gneiss (labelled ‘diorite’ on the plan) vases are recorded along the route to the Nile.

At Stelae Ridge, Engelbach records the presence of five cairns and three cairns, together comprising the eight that make up the Stelae Ridge group. To the north and west of Stelae Ridge he notes the presence of ‘amethyst diggings’, which are the mines now known to have produced carnelian (Shaw *et al.* 2010, 302). To the east a point marks a hill with an illegible stela and pit.

---

[173] See Engelbach (1933, 67); Shaw and Bloxam (1999, 17); and Shaw *et al*. (2010, 299–302) for Middle Kingdom activities at Quartz Ridge.

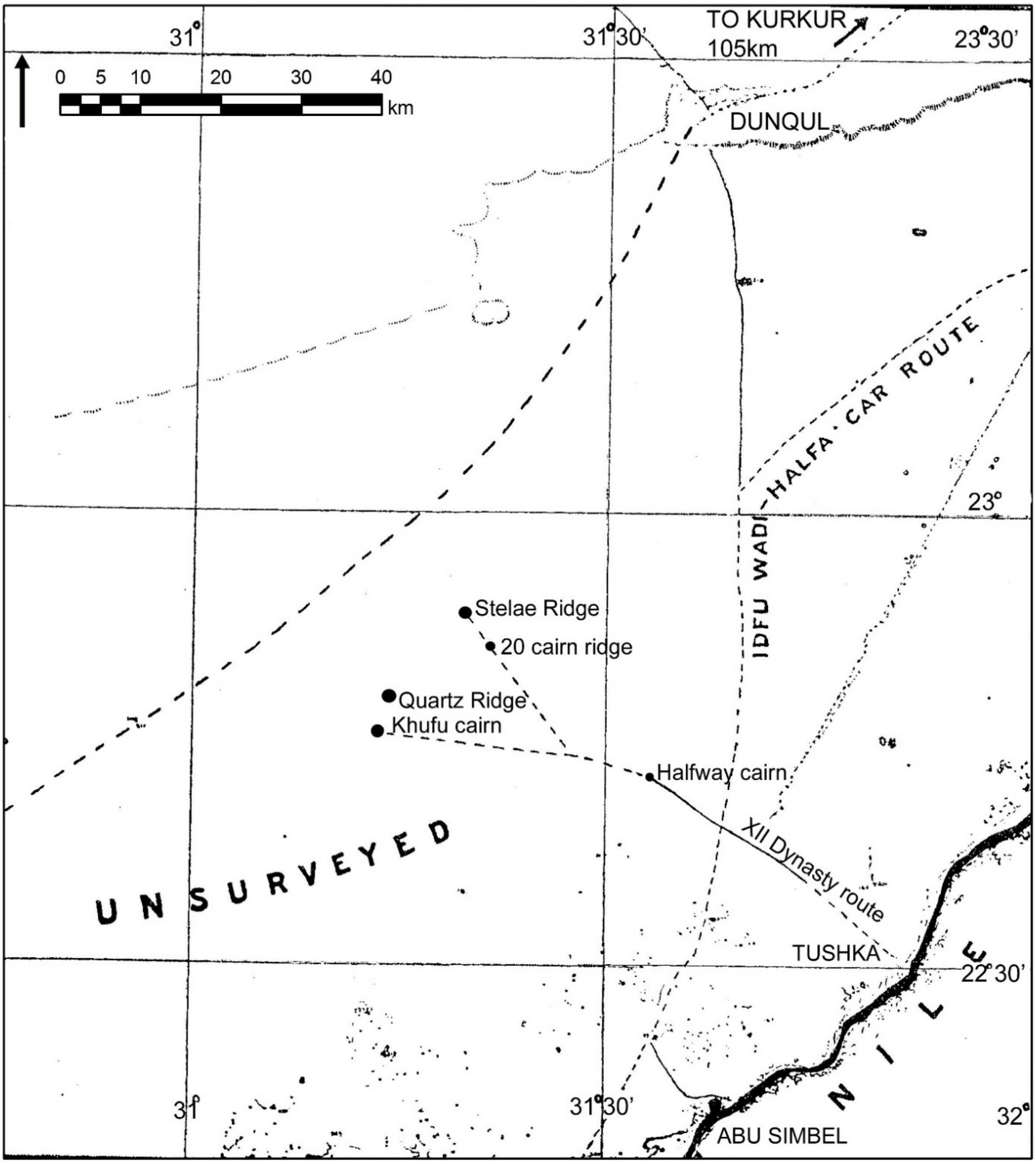


Fig 3.2: Engelbach's 1:500,000 map of the Gebel el-Asr quarrying region. Arrow indicates north. (Modified from an original in Engelbach 1939).

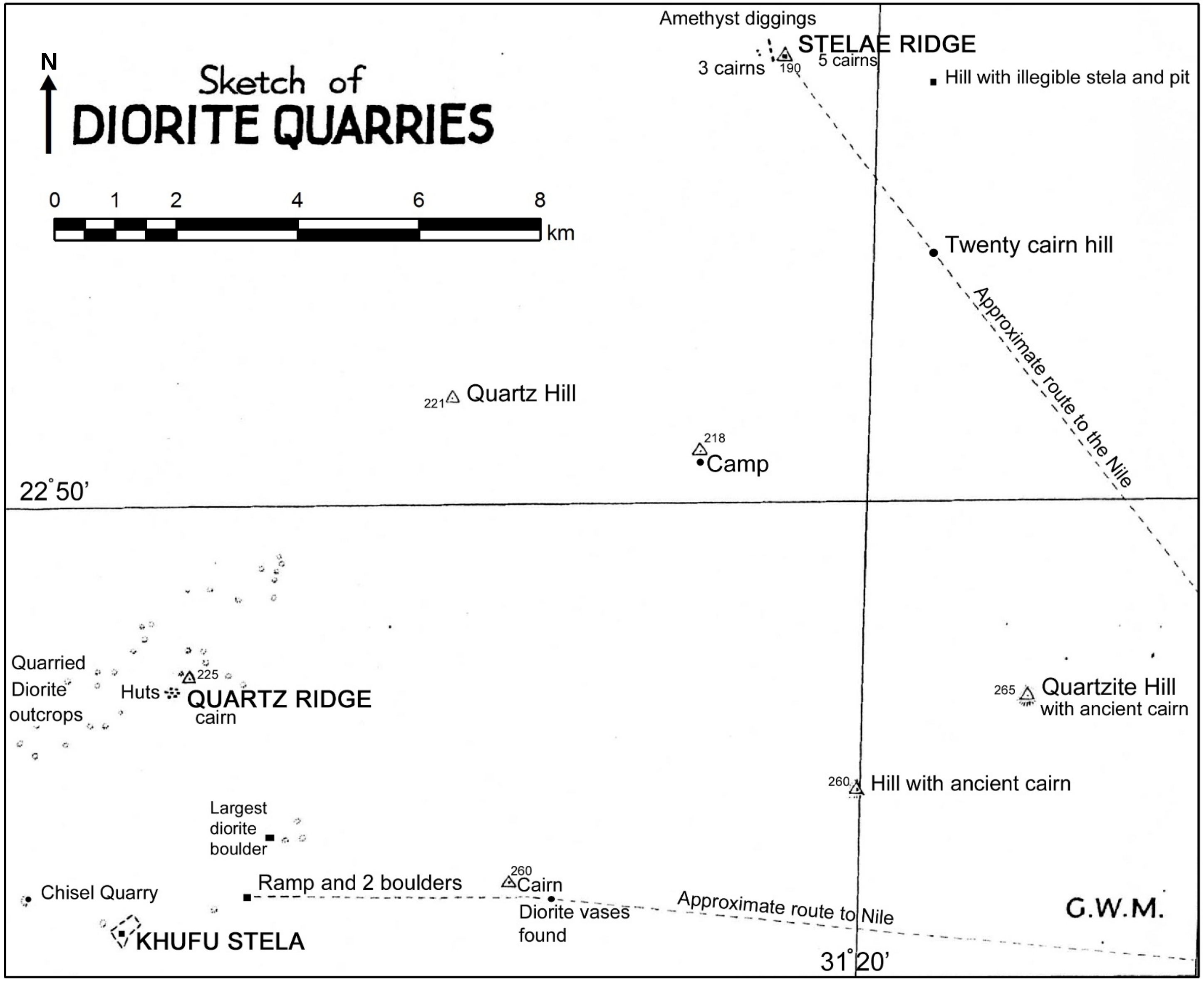


Fig 3.3: Engelbach's 1:100,000 scale sketch of the Gebel el-Asr quarries. The product of the quarries is incorrectly described as 'diorite' but is now known as 'gneiss' (Original in Engelbach 1939).

The map shows some considerable distance between the carnelian mines at Stelae Ridge and the centre of Middle Kingdom gneiss quarrying at Quartz Ridge (Shaw *et al.* 2010, 299–302). Both locations are linked to tracks back to the Nile, labelled ‘approximate route to the Nile’ on the map, which join up off the map to the east, as shown on Fig 3.2. However, the area between Stelae Ridge and Quartz Ridge is not empty. Engelbach identifies two hills with ancient cairns and a location described as ‘Quartz Hill’, which may also have had a cairn.[174] The feature labelled ‘Quartzite Hill with ancient cairn’ is notable because its modern name is ‘Gebel el-Asr’, and it has given its name to the site.

Another significant landscape feature is south-east of Stelae Ridge on the route towards the Nile and is marked ’Twenty cairn hill’. This is presumably the same location labelled ’20 cairn ridge’ in the small scale map of the Gebel el-Asr region in section 3.3.1 and Fig 3.2 above. The two different names reflect some ambiguity about the precise nature of this feature. In his first report, Engelbach (1933, 69) described a ridge with 13 cairns 5.2km from Stelae Ridge on a bearing of 144°, which would place it in roughly the same location as ’Twenty cairn hill’ on the map of the gneiss quarries (Fig 3.3) and ’20 cairn ridge’ on the map of the Gebel el-Asr region (Fig 3.2). In his second report Engelbach (1939, 388) describes ’20 cairn ridge’ as having ‘about 20 cairns’ and says it was located in a direct line between Stelae Ridge and Tushka, with Stelae Ridge just visible from it. The position of both features is broadly consistent but the variation in the description of the topographic feature and number of cairns suggests there may have been more than one rise, south-east of Stelae Ridge, with multiple cairns. For ease of reference ‘20 cairn ridge’ and ‘20 cairn hill’ will be assumed to be in roughly the same location and described by the single label ’20 cairn hill’ until more information provides a satisfactory resolution.

3.4. Stelae Ridge on the CORONA photographs

Only CORONA image DS1105-2235DF077 from 1968 covered the site at Stelae Ridge (Fig 3.4), but that strip shows several significant archaeological features in the area.[175] Three cairns are clearly visible on the CORONA image as three small, dark, roughly circular features aligned north-south (Fig 3.4). The darker colour of the features, compared to the surrounding environment, revealed that they were higher than the desert around them and were therefore casting a shadow which was recorded by the CORONA camera. The northernmost feature is *c*. 9m, the middle one *c.* 7m and the southern one *c* 6.5m in

[174] Research by the Gebel el-Asr Project revealed that the ‘camp’ on the map was actually a modern camp, probably one of those used by Engelbach’s expedition (Ian Shaw pers comm).
[175] For the origin and specifications of CORONA satellite photographs see Chapter, 2, section 2.2.1.

diameter (Fig 3.4). There is *c.* 4m between the northern feature and the central one and *c.* 7.5m between the central one and the southern one.

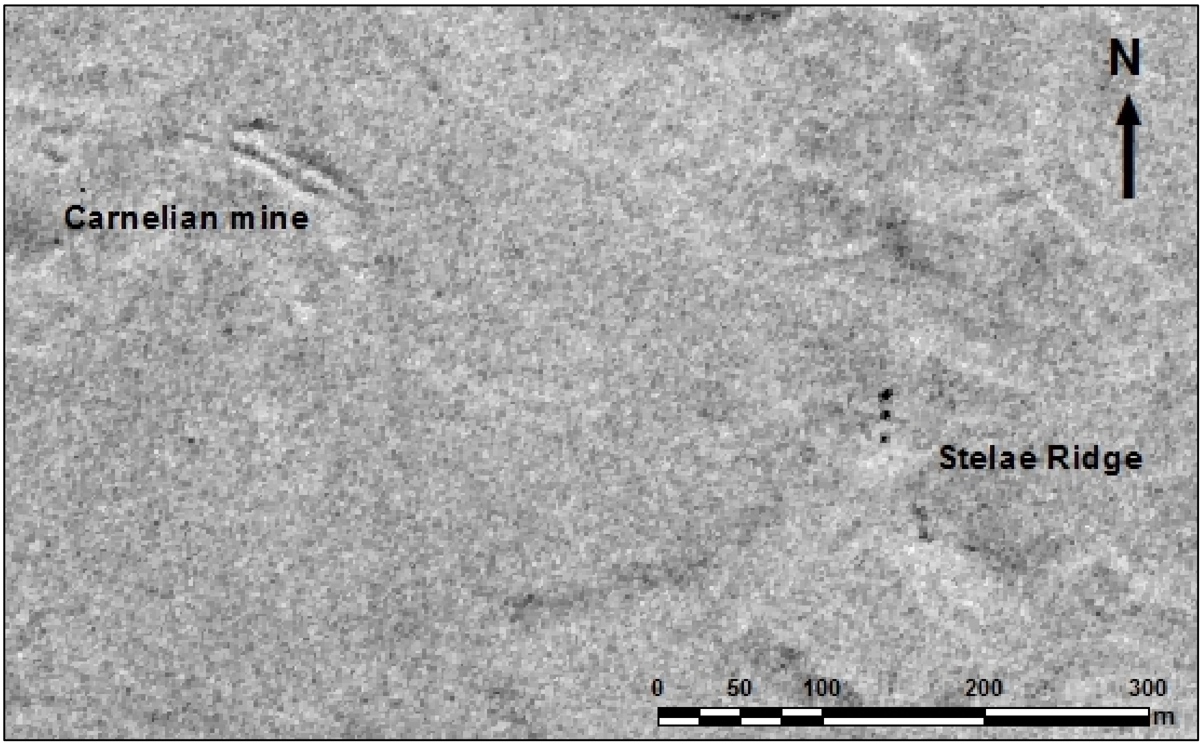


Fig 3.4: Stelae Ridge from the 1968 CORONA image 1105-2235DF077, obtained from the Centre for Advanced Spatial Technology, University of Arkansas/USGS.

The alignment, size, number and distance between these features on the CORONA image corresponds to the alignment, size, number and distance between cairns VI, VII and VIII on Engelbach's (1939) sketch plan of Stelae Ridge (Fig 3.5).

A slightly darker area is visible *c.* 40m south-east of the southernmost cairn of the northern group. Engelbach's (1939) sketch plan shows the southern group of cairns *c.* 37m south-east of the northern group. Allowing for the imprecision inherent in a sketch plan, this darker feature is in roughly the right location on the CORONA image. The absence of any clear definition of the cairns in the southern group might suggest that even by 1968 they had suffered some damage. Alternatively it could be due to the smaller size of the cairns, atmospheric conditions, or the alignment of the cairns relative to the sun and the satellite's camera.

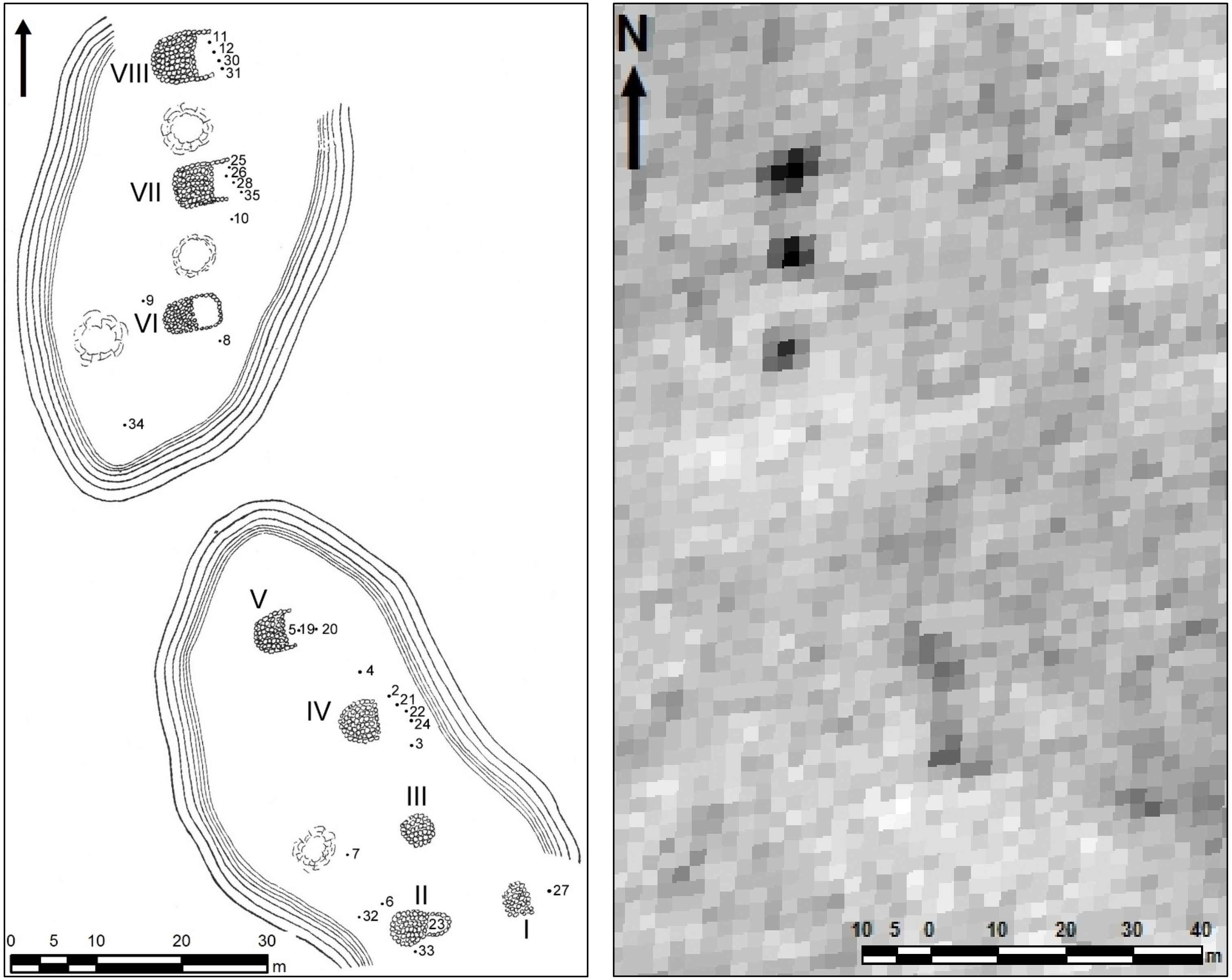


Fig 3.5: Comparison of Engelbach's (1939) sketch plan (left) and the Stelae Ridge features recorded by the 1968 CORONA satellite photograph (right), provided by the Centre for Advanced Spatial Technology, University of Arkansas/USGS. On Engelbach's plan, large Roman numerals represent cairn numbers, small Arabic numerals represent artefacts. The CORONA image appears pixelated because of the resolution of the photograph.

Considering the location, alignment and size of the three northern features shown in the CORONA photograph there can be little doubt that they represent the remains of the cairns at the northern end of Stelae Ridge. The large carnelian mine located *c.* 300m north-west of the cairns in Fig 3.4 fits Engelbach's description of the 'large excavations' that were near Stelae Ridge (Engelbach 1933, 69). There are no other candidates for Stelae Ridge in the right location on the CORONA image and in such close proximity to a large mine or mines.

3.5. Stelae Ridge on the Quickbird satellite imagery

The 2009 Quickbird image (Fig 3.6) of the Stelae Ridge area shows the main anthropogenic features around the site.[176] These features include the Gebel Uweinat road to the east of the site and the large Sadat canal and its associated spoil heaps. The Sadat canal is also known as the 'main canal' because of the presence of other secondary canals of the Tushka Project.

The high resolution of the Quickbird image also makes it possible to identify two secondary roads, one running eastwards from the Gebel Uweinat road and crossing the main canal. The other road runs north from the Gebel Uweinat road, where the latter turns westward. At the junction of this latter road and the Gebel Uweinat road is a small compound with buildings, probably associated with the construction works on the Tushka Project.

A more detailed view of the mining area (Fig 3.7) shows the surviving Middle Kingdom remains and elements of modern disturbance. Marks made by JCB buckets are visible in several places across the image, including a large polygonal area that was subject to extensive re-working by modern plant and is marked 'modern disturbance' on the figure.

To the north of the area of modern disturbance are the remains of some of the Stelae Ridge cairns. JCB scars attest that these have also been damaged, but they are less disturbed than the area to the south. Almost 100m to the west of Stelae Ridge is a short linear feature, aligned north-south. This is the remains of another cairn demolished recently. Almost 300m north-west of Stelae Ridge is the main carnelian mining area. The mines are delineated by raised mounds of excavated spoil surrounding sunken interior areas and vary in size. Some of the smaller features may be wells or other archaeological features, but this cannot be determined from the satellite image. The only recognisable feature is a small intact cairn located *c.* 70m south-east of the largest mine.

---

[176] For the origin and specifications of Quickbird imagery see Chapter 2, section 2.2.3.

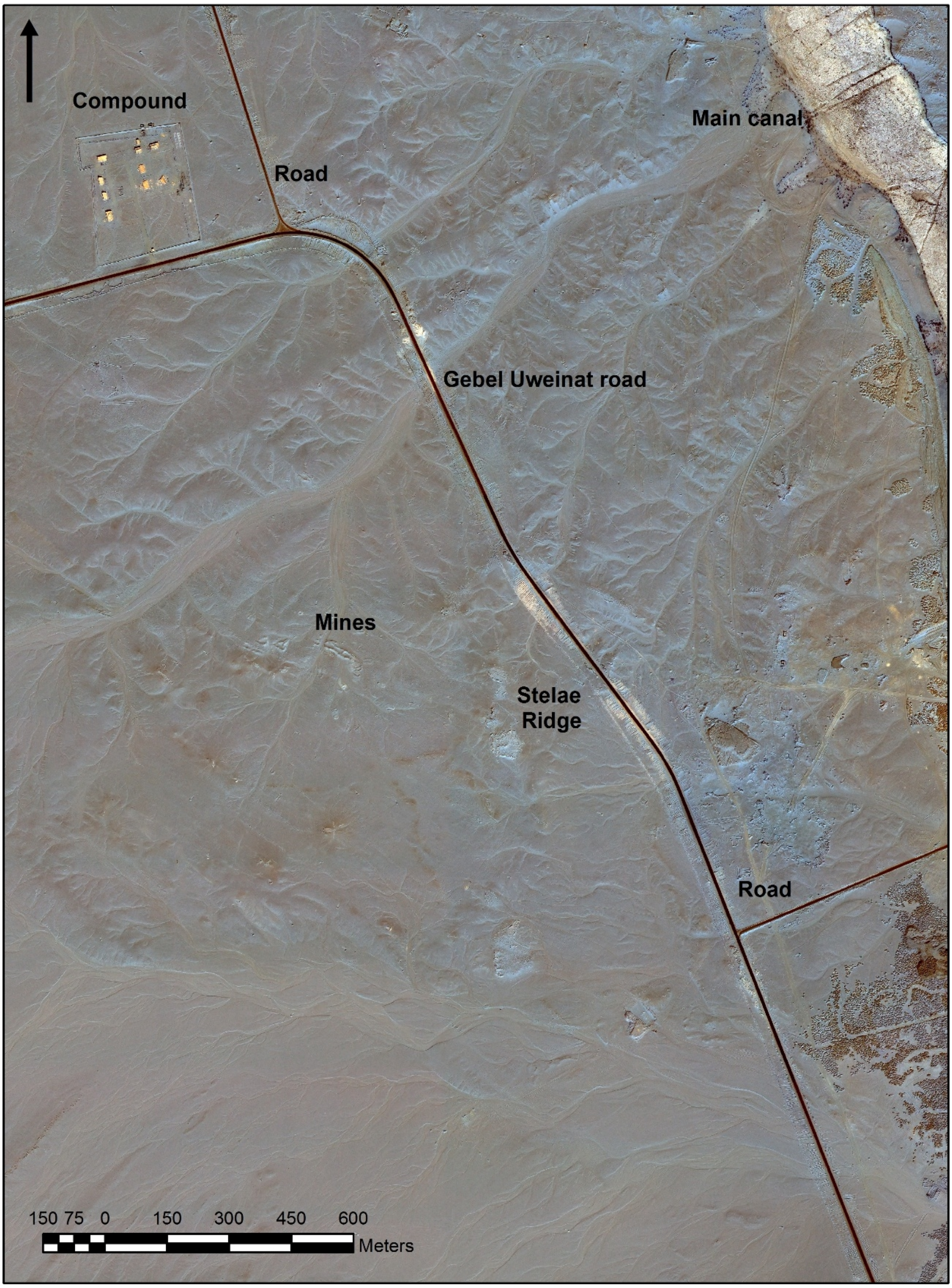


Fig 3.6: Pan-sharpened 4-band Quickbird image of Stelae Ridge from 2009. (Satellite image © European Space Imaging / Digitalglobe)

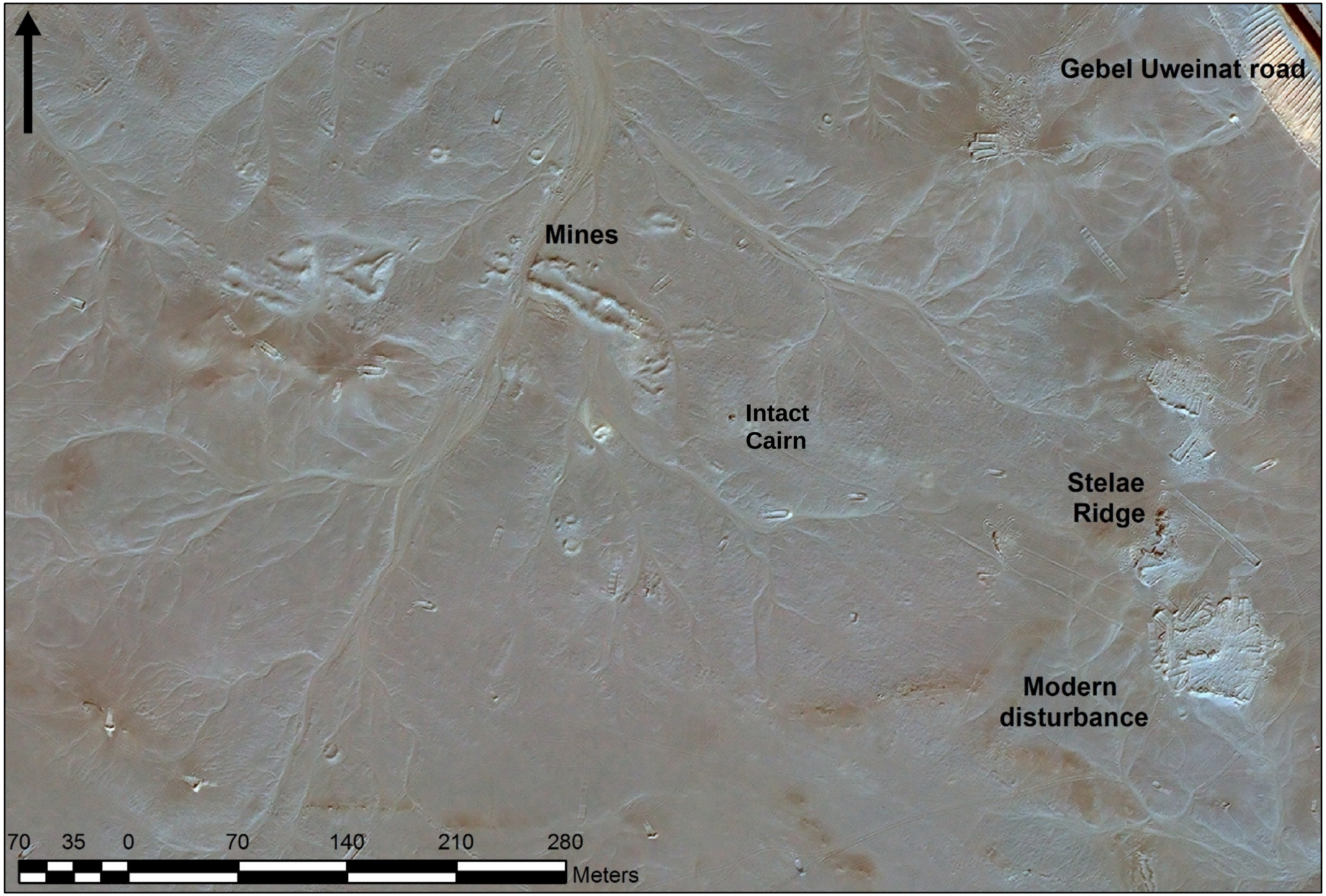


Fig 3.7: Detailed view of the Stelae Ridge mining area, from the pan-sharpened 4-band Quickbird image. (Satellite image © European Space Imaging / Digitalglobe)

3.6. Gebel el-Asr Project survey

The Gebel el-Asr Project undertook a survey of the quarrying area using a differential GPS to produce a geo-referenced database of archaeological sites with geographical coordinates accurate to 5m (Bloxam 2003b, 37) that can be imported directly into the GIS to produce maps of the archaeological sites around the Gebel el-Asr quarries (Fig 3.8).

Most of the excavation work of the Gebel el-Asr Project was focussed on the Gebel el-Asr gneiss quarries to the south.[177] Due to the extent of the damage to the Stelae Ridge cairns, they were only recorded as point data, although several mines to the west survived sufficiently well to be recorded in more detail (Fig 3.9 and Fig 3.10). The Gebel el-Asr Project data cannot therefore provide a detailed plan of the remains at Stelae Ridge for comparison with the records made by Engelbach, although it does help to confirm the location of the site.

3.7. Archaeological research at Stelae Ridge in 2012

Although the records made by previous archaeological expeditions and the two satellite images reveal much about the location and layout of the archaeological remains at Stelae Ridge, additional information was necessary to contextualise the site and undertake the visibility analysis. The only detailed plan of the layout of Stelae Ridge was the sketch made by Engelbach, but this was only a sketch and was difficult to relate to more recent data. The Gebel el-Asr Project survey had only recorded the cairns as point data, so could not assist in understanding their layout. The CORONA photograph was too low resolution to permit detailed comparison with Engelbach’s plan and the damage that had occurred to the site since made it difficult to relate to the Quickbird image, despite the latter’s high resolution. There was also a need to record more details about the peripheral cairns and other features than could be obtained from the Gebel el-Asr Project data or the Quickbird imagery.

[177] See summary of the Gebel el-Asr Project work in Shaw *et al.* (2010).

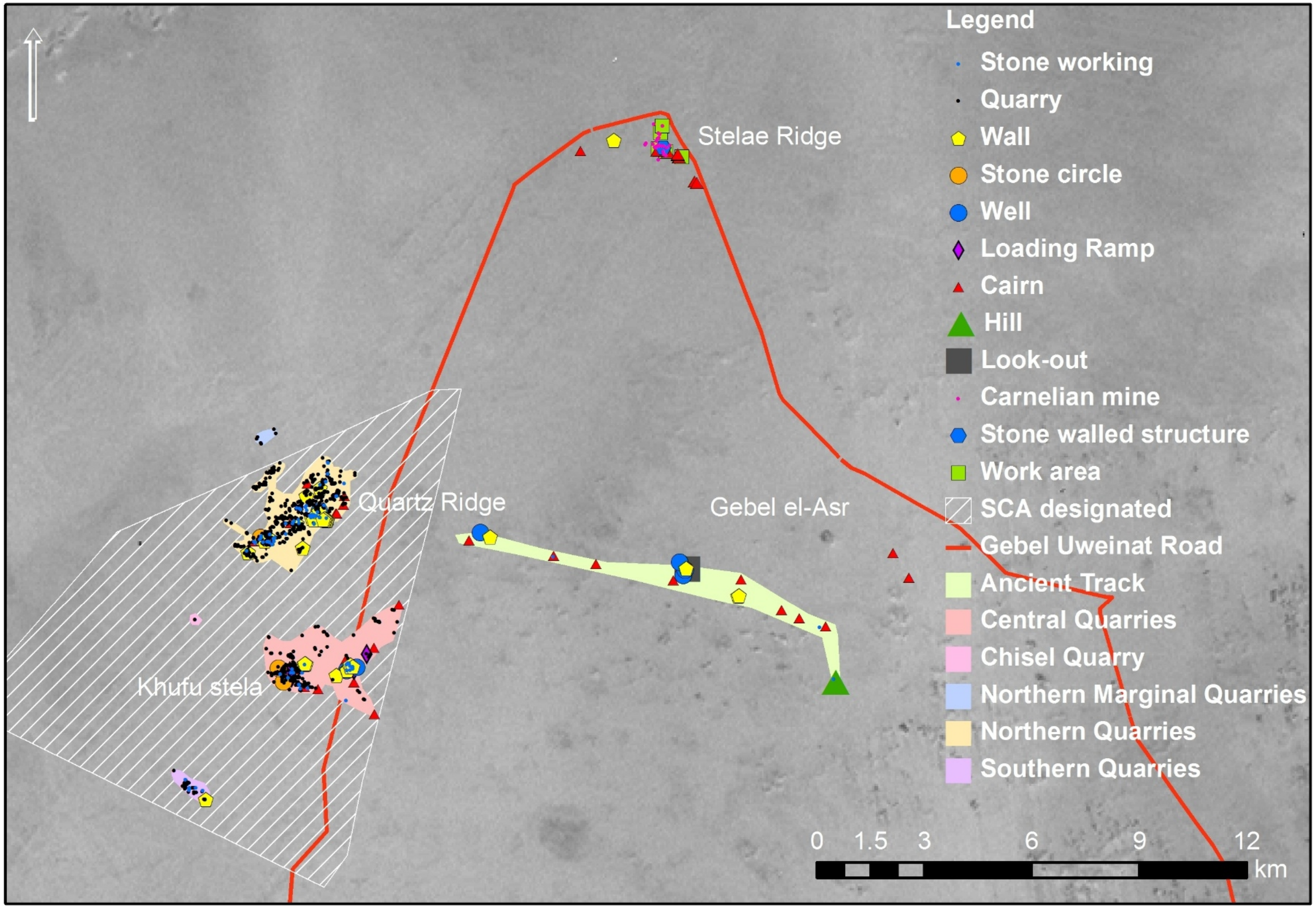


Fig 3.8: Gebel el-Asr Project survey data, with underlying 1972 Landsat 1, 60m resolution MSS image. (Satellite image p188r44_1m19721109 available from the USGS).

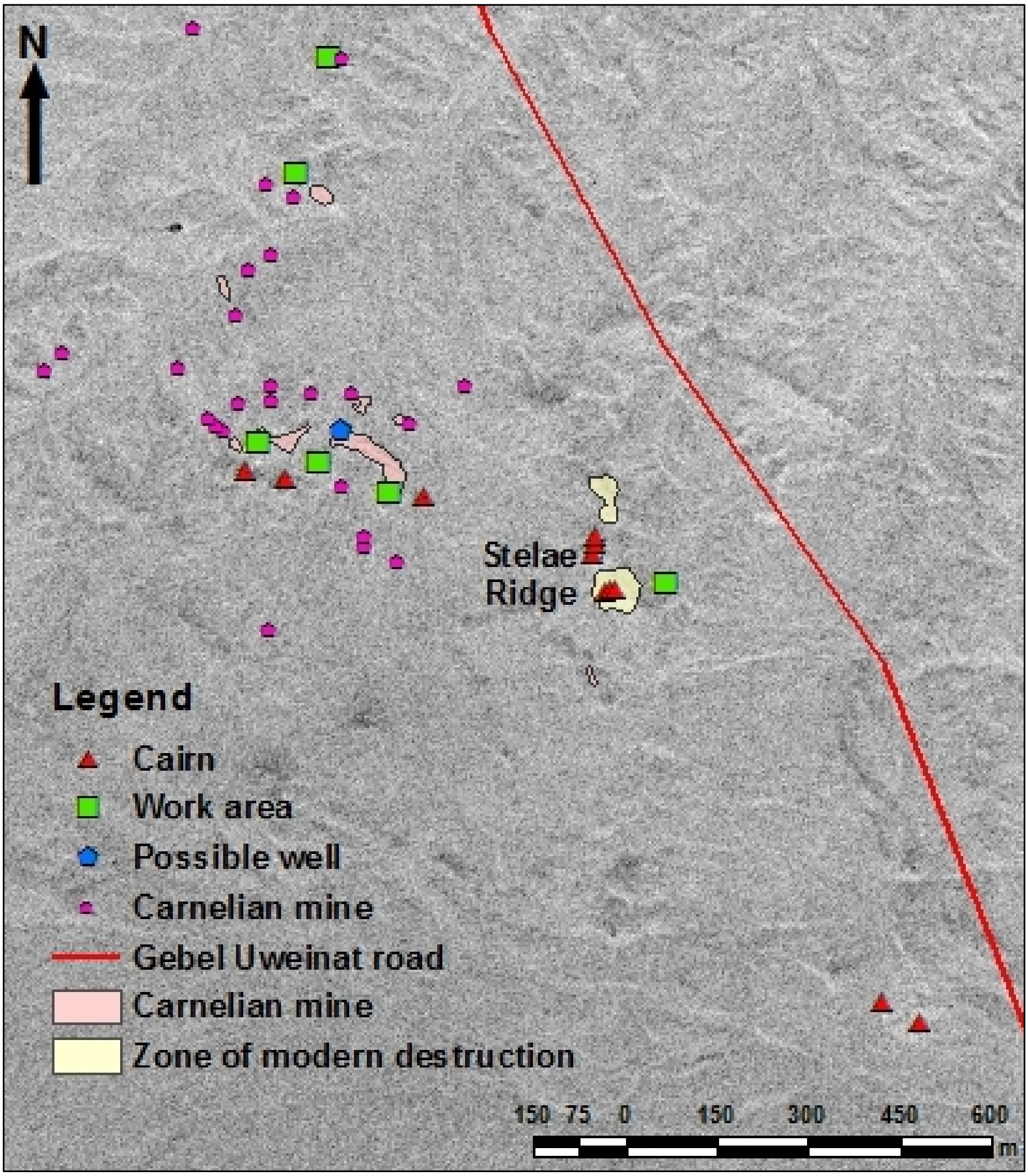


Fig 3.9: Gebel el-Asr Project GPS survey data of Stelae Ridge with underlying 1968 CORONA satellite image DS1105-2235DF077. (CORONA image from the Centre for Advanced Spatial Technology, University of Arkansas/USGS).

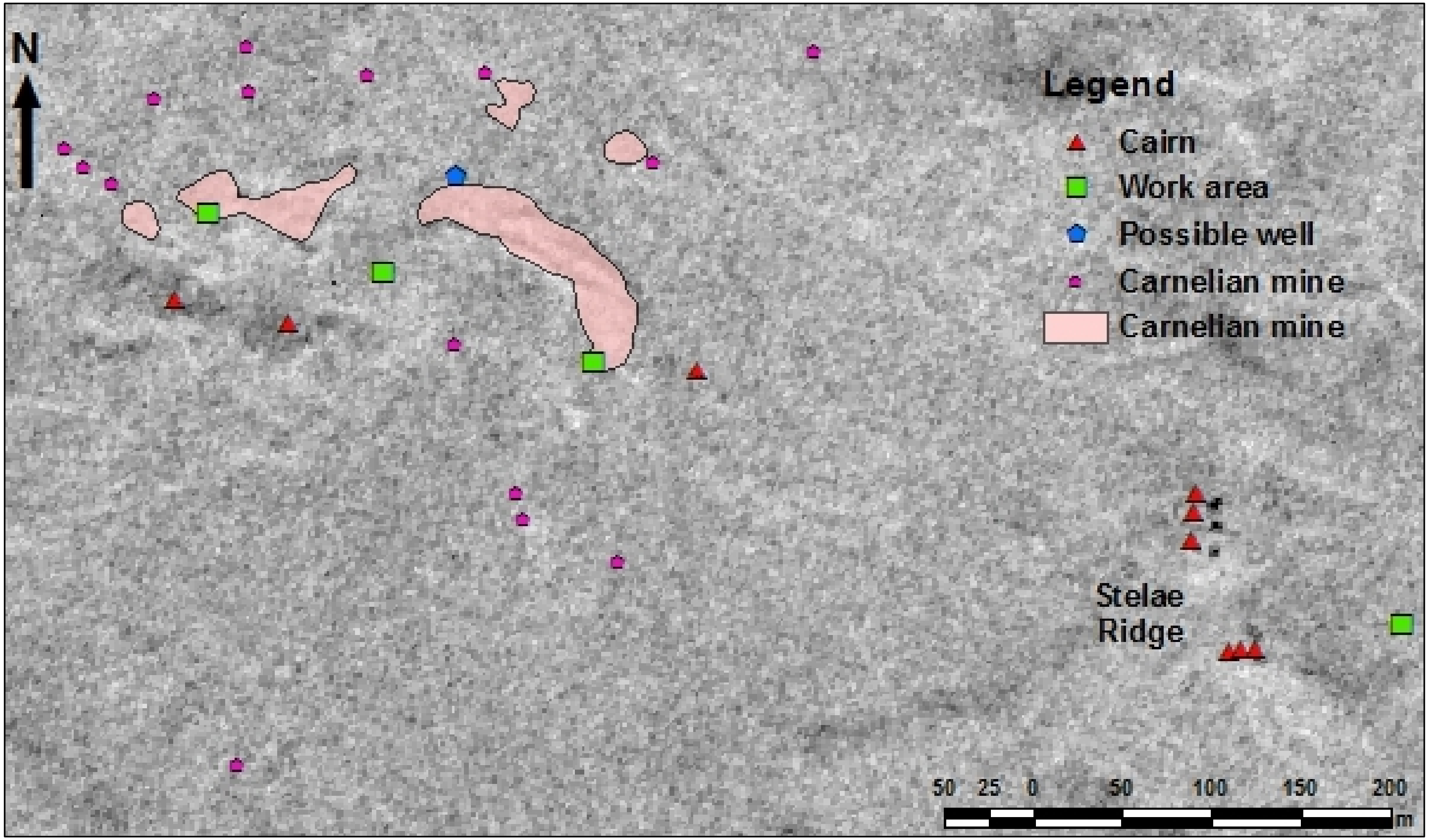


Fig 3.10: Comparison of the area around Stelae Ridge in the 1968 CORONA image DS1105-2235DF077 and the Gebel el-Asr Project data. Note the difference in location between the three northern Stelae Ridge cairns on the satellite photo and the GPS survey data. (CORONA image data from Centre for Advanced Spatial Technology, University of Arkansas/USGS).

In order to improve understanding of the remains and gain familiarity with the landscape, a brief season of archaeological research was undertaken at Stelae Ridge in December 2012. This was intended to comprise archaeological survey of the surviving remains, topographic survey of the surrounding landscape and phenomenologically influenced research recording the author's experience of visibility, for comparison and validation of the GIS visibility analysis. Originally fieldwork lasting 10 days at the site was planned, but due to administrative problems the actual time on site was reduced to two days.

3.7.1. Aims

The original aims of the research were:

1. To make an accurate plan of the location, size and height of the surviving cairns and any other relevant archaeological features on Stelae Ridge to enable identification of the cairns recorded by Engelbach.

2. To record surviving peripheral cairns and any other features of interest.

3. To make a topographic survey of the area around Stelae Ridge, to assist in the creation of a hybrid digital terrain model as described in Chapter 4, section 4.2.4.

4. To survey sufficient features, including mines, the modern road and any other features of relevance, to provide the control points that would enable the survey data to be transformed in the GIS.

5. To gain familiarity of the landscape and record the author's experience of visibility at the site to compare with and inform interpretation of the GIS visibility analysis.

Due to the very short amount of time we were permitted on the site, these aims had to be adjusted. Fieldwork was limited to archaeological survey of the remains at Stelae Ridge and its immediate surroundings. Aim 1 was met completely through thorough survey of the features at Stelae Ridge. Aim 2 was partially met through survey of some peripheral cairns, although it had been hoped that more peripheral cairns could be recorded. Aim 4 was met through survey of several mines, old excavation trenches, part of the Gebel Uweinat Road and areas of modern activity. Aim 5 was partially met through a record of the author's experiences of visibility, photographs, a 180° photographic panorama of what was visible from Stelae Ridge and a 'circular view' recording in graphic form what was visible from the same location. Aim 3, the topographic survey, had to be abandoned due to time constraints.

3.7.2. Archaeological Survey

As the project did not have access to a differential GPS system, the survey was undertaken with a Leica TCRP 1205 robotic Total Station. Each archaeological feature was recorded with a series of measurements taken around the external edge and one or more taken at the highest point. Ideally the surviving height and shape of all the cairns and partial cairns would have been recorded by taking a large number of points across their surface to create a point cloud that could be interpolated in the GIS to produce a three dimensional model of the cairn. This had to be abandoned due to the short time the site was accessible. Where cairns had obviously been demolished by plant, the outline of the remains was recorded in two dimensions, but no record was made of the height since the original height had undoubtedly been altered by the demolition process. For the same reason the area of intensive modern disturbance to the south of the Stelae Ridge cairns, first surveyed by the Gebel el-Asr Project (Shaw *et al.* 2010, Fig. 9), was recorded in outline only.

The survey was based upon three station points given local coordinates based upon a site grid because there were no ground control points visible in the Quickbird satellite image and present on the ground, which could provide geographic coordinates for the survey. The site grid began with a point between two of the surviving cairns on Stelae Ridge. This point was given the grid co-ordinates 1000.065; 1000.051; 100.035 (Easting; Northing; Height). This point became Survey Station 1 (ST1) of the three permanent survey stations:

- STI – Between two Cairns (numbered 011 and 012) at Stelae Ridge with the coordinates 1000.065; 1000.051; 100.035.
- ST2 –10m east of ST1 with the coordinates 1005.010; 1000.020; 99.467.
- ST3 – West of a partially demolished cairn (cairn 013 on the survey plans) to the west of Stelae Ridge, with the coordinates 893.367; 987.323; 97.359.

Following completion of the survey a projective transformation[178] was undertaken in ArcGIS to transform the survey data into UTM 36N coordinates using the Quickbird satellite image as a reference. Fourteen ground control points were chosen, located across the 2012 survey data and also identifiable in the Quickbird image. The resulting transformation had a RMSE of 0.880531m, which is a good result, considering that the resolution of the Quickbird image is only 0.5–0.6m. It should be noted that the transformed 2012 survey data will also be

[178] Vector transformation is summarised in Conolly and Lake (2006, 87) and is undertaken using the 'Spatial Adjustment' toolbar in ArcGIS 10.1 http://resources.arcgis.com/en/help/main/10.1/index.html#//01m800000030000000, last accessed 15 July 2014.

subject to the same error as the Quickbird image which provided the ground control points for the transformation.[179]

It was also necessary to transform the heights of all the 2012 survey point data into heights above mean sea level. The SRTM provided the height data and ST1 was chosen as the reference location. ST1 had been given a height of 100.035m for the 2012 survey. The SRTM indicated that at ST1 height above mean sea level was actually 192m. The difference between the actual height of 192m and the survey height of 100.035m was 91.965m and the height above sea level of any given 2012 survey point could therefore be obtained by adding 91.965 to the height recorded during the survey:

Height above sea level = Survey height + 91.965m

A new column named 'ELEV' was added to the attribute tables of all point data from the 2012 survey and populated with the results of this formula using the Field Calculator[180] function of the ArcGIS attribute table menu.

It is recognised that this method is less than perfect because the SRTM has a resolution of 3 arc seconds, or *c.* 87m at Stelae Ridge, and cannot therefore give a very precise height for ST1 or any other given survey point. However, the SRTM has the best combination of accuracy and resolution currently available to this project[181] and the *c.* 87m resolution will have less impact in the flat area around Stelae Ridge than it would in a more topographically varied environment. Using the SRTM to create a formula for the adjustment of the survey points also ensures that the relative differences in the heights of the 2012 survey points are preserved in the resulting height above mean sea level, even where, due to its resolution, the SRTM would record the same height for multiple survey points. Combining the SRTM data and the 2012 survey data therefore ensures the heights are related to known sea level, but the fine height gradations permitted by the 2012 survey are retained and the surviving heights of the archaeological features can therefore be calculated.[182]

---

[179] For the accuracy of the Quickbird image see Chapter 2, section 2.2.3.
[180] For the Field Calculator in ArcGIS see http://help.arcgis.com/en/arcgisdesktop/10.0/help../index.html#//005s00000025000000, last accessed 15 July 2014.
[181] See the discussion in Chapter 4, section 4.2 concerning the available DEM and their respective accuracy and resolution.
[182] It was important to be able to calculate the heights of the surviving cairns to inform the target heights for visibility analysis of the cairns and to assess whether they were likely to affect visibility to or from the courts (Chapter 2, section 2.6.3).

Survey results

An overview of the survey area is shown in Fig 3.11 and more detailed results in Fig 3.12, Fig 3.13 and Fig 3.14. The total area surveyed (Fig 3.11) was *c.* 0.43km^2, but due to time constraints the survey within this area was not exhaustive. Four mines, a possible well, two Gebel el-Asr Project excavation trenches, three survey stations, an area of modern destruction, part of the Gebel Uweinat road and 17 cairns, including heaps of stones which may represent demolished cairns or modern mounding of ancient cairn material, were surveyed.

Modern excavation trenches and areas of modern destruction were easy to delineate. The possible well and the mines were also relatively well preserved. Their external and internal dimensions could be determined from the surviving stonework of the well, and the mounded spoil heaps of the mines. The most difficult features to survey were the cairns, because in most cases these had been damaged. Cairns 014 and 017 (Fig 3.12 and Fig 3.13) displayed little or no damage and cairns 011 and 012 (Fig 3.14) were largely intact. Cairns 013, 015 and 016 (Fig 3.13) had been pushed over by plant. Cairns 04-010 (Fig 3.14) appear as piles of stones, significantly affected by modern earth moving equipment. These piles were surveyed and given cairn numbers, but the evidence suggests that, with the possible exception of cairn 06,[183] they are little more than the remnants of the original structures. Cairns 01-03 are located in the centre of an area of extensive modern activity. While they may include stones from the original Middle Kingdom structures, they are not *in situ.*

---

[183] See below for further details concerning cairn 06.

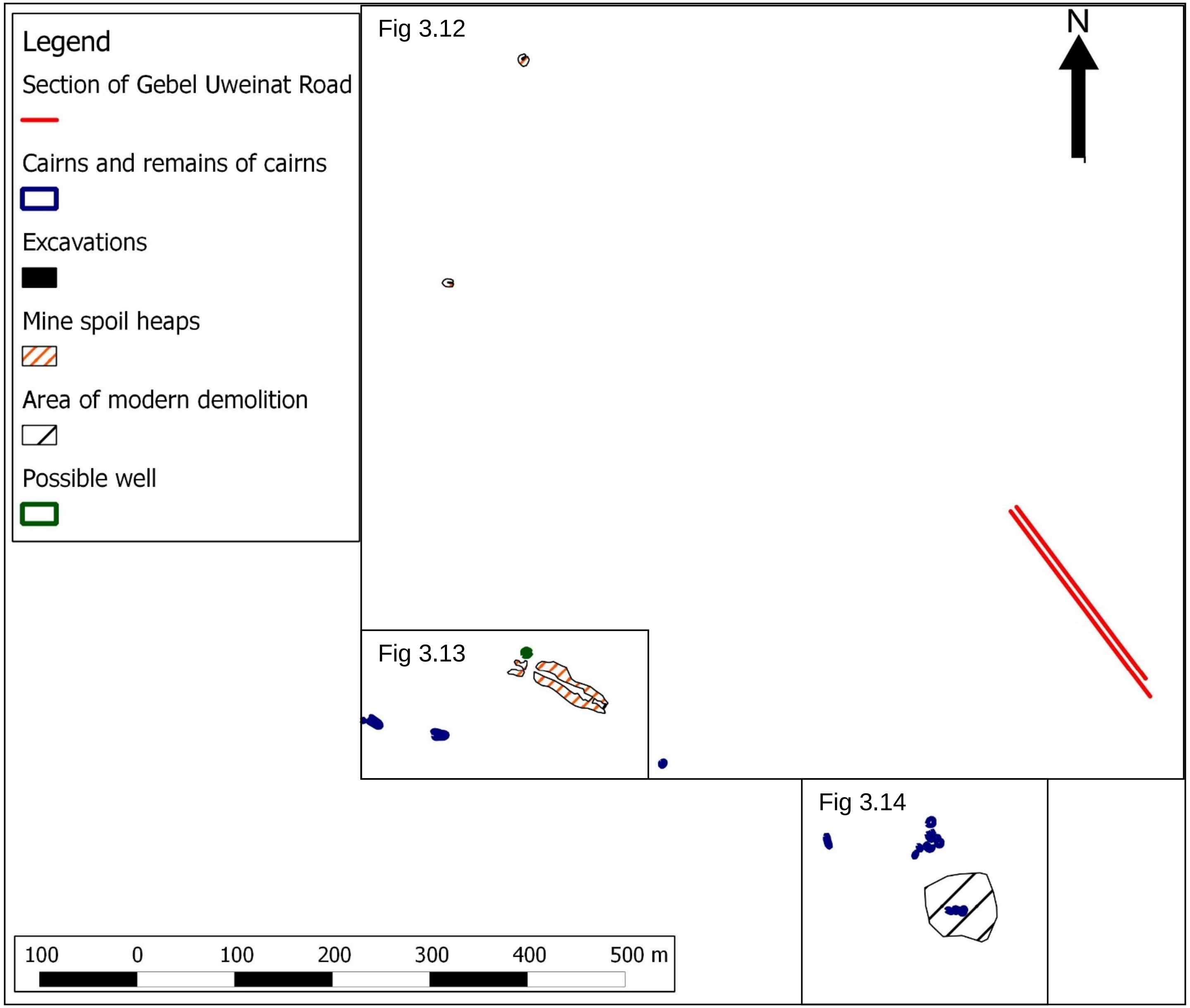


Fig 3.11: Overview of all the features surveyed during the 2012 survey. Image created by the author in QGIS 1.8 using survey data.

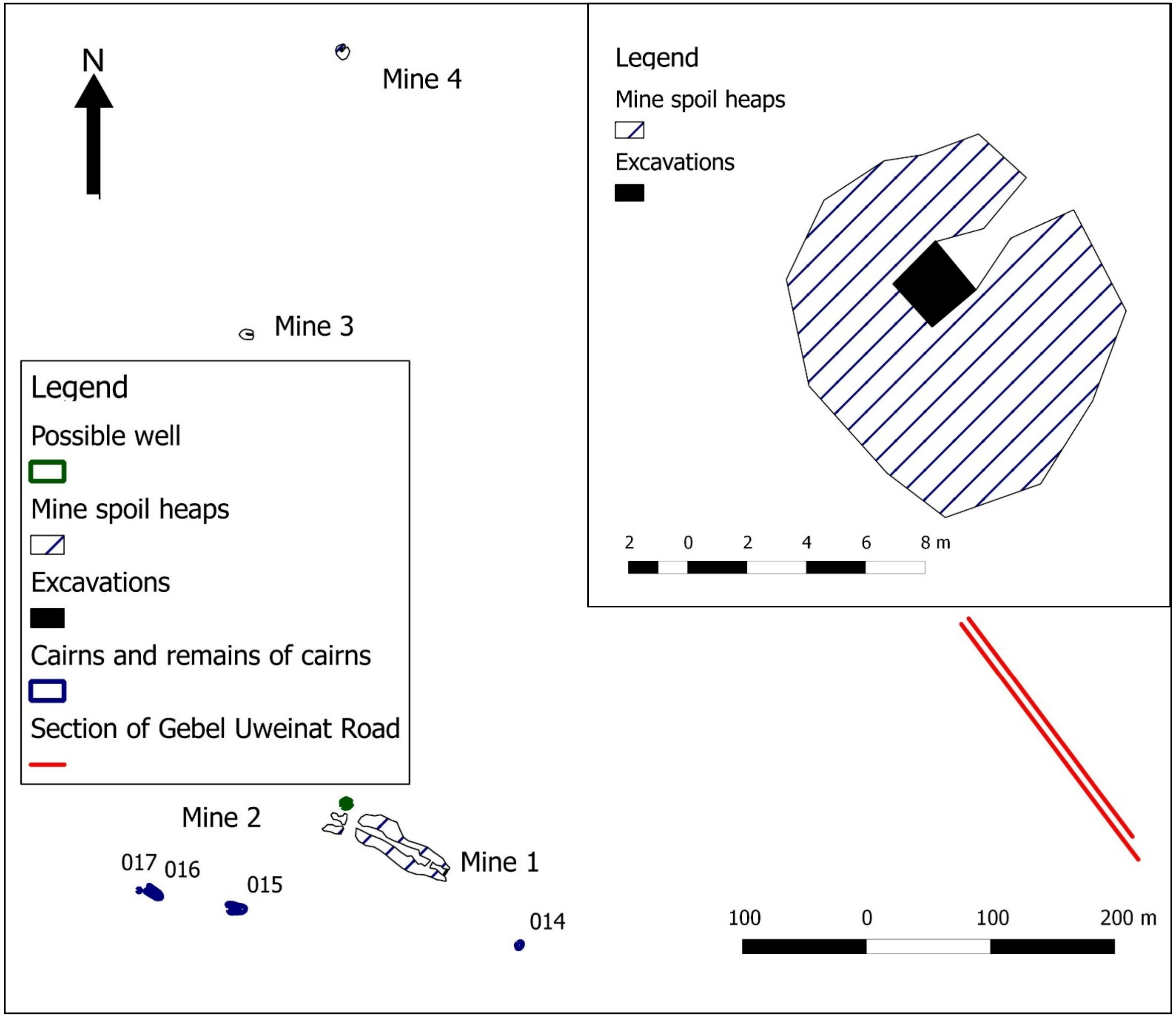


Fig 3.12: The northern part of the survey area, including a detail (inset) of Mine 4 showing the Gebel el-Asr Project excavation trench. Image created by the author in QGIS 1.8 using survey data.

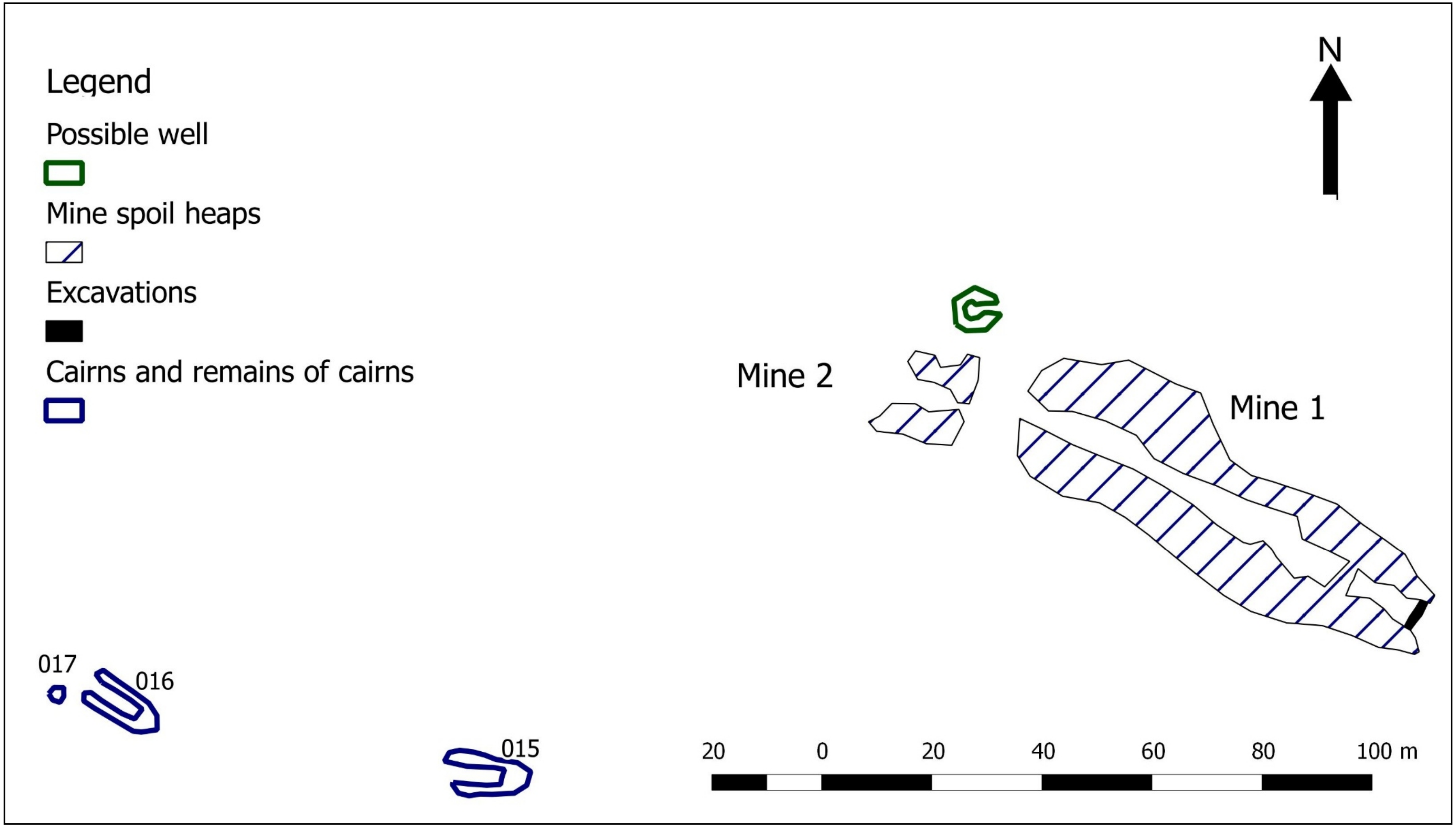


Fig 3.13: The south-western part of the survey area showing the largest mine (Mine 1), possible well and cairns 015 to 017. Image created by the author in QGIS 1.8 using survey data.

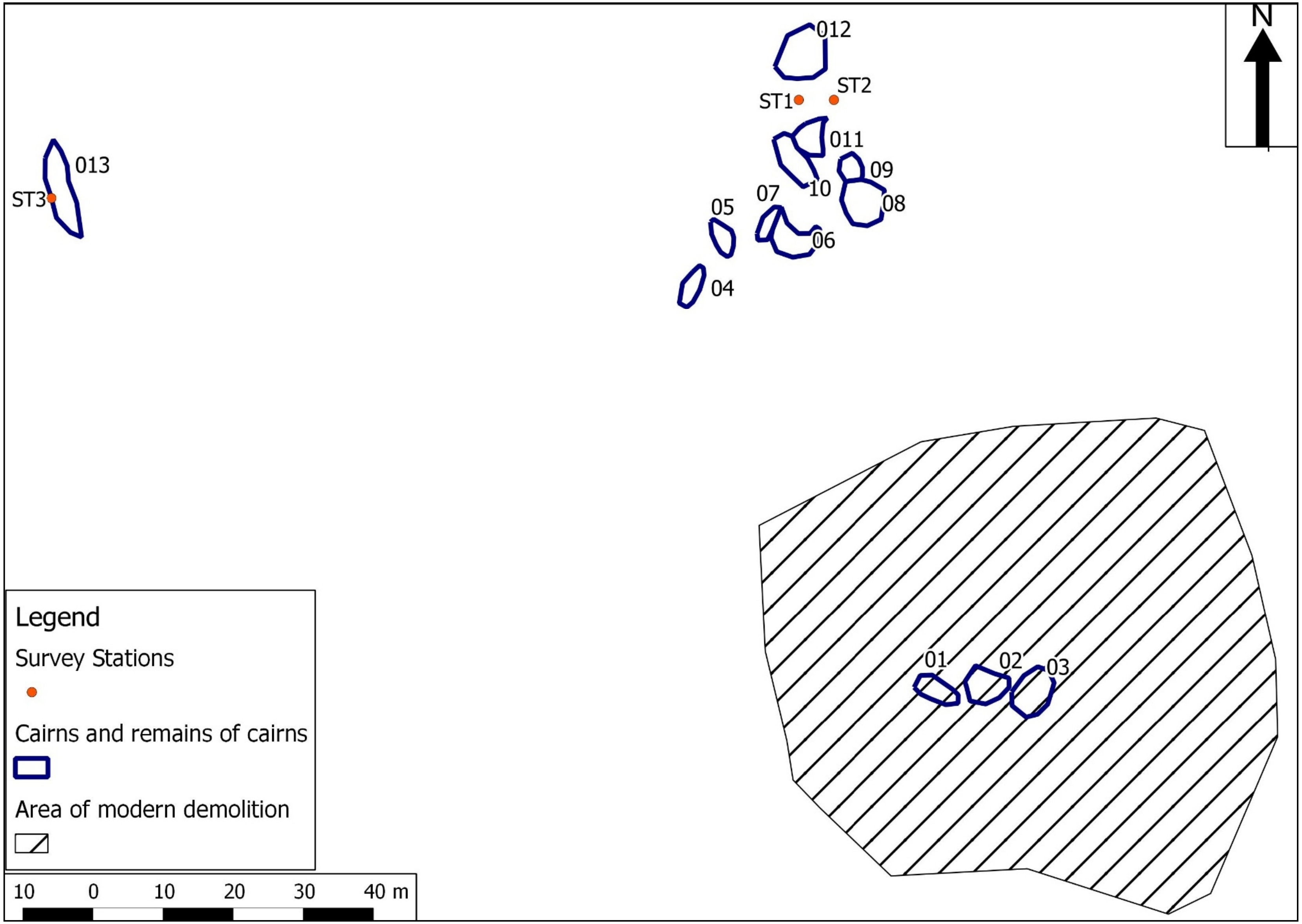


Fig 3.14: Survey area around ST1 to ST3. Image created by the author in QGIS 1.8.

Identification of the Stelae Ridge cairns sketched by Engelbach

The area occupied by cairns 01–012 (Fig 3.14) was identified as Stelae Ridge from a number of pieces of evidence. It had originally been identified by the Gebel el-Asr Project and recorded as such in their survey,[184] but the 2012 survey recorded additional evidence that confirmed this identification.

Fig 3.15: Photo of a blank stela found at Stelae Ridge in 2012. Scale is 0.25m (Author photo).

Engelbach (1933, 68) describes Stelae Ridge as being 13km north-east of the gneiss quarries on a bearing of 42˚, which is the same approximate location as the area surveyed in 2012. He also describes the eight Stelae Ridge cairns as being 'in the neighbourhood' of 'large excavations' that produced a 'large quantity of coloured and partly translucent quartz (Engelbach 1933, 69)'. The 2012 survey area contains a number of mines that fit this description. In particular, there is a large mine; Mine 1 on the survey plans (Fig 3.13), which is located 300m west of the cairns surveyed in 2012 and fits Engelbach's description of 'large excavations'.

Fig 3.16: Stone 'pyramidion' found at Stelae Ridge in 2012. Scale is 0.25m. (Author photo)

The nature of features recorded in Fig 3.14 confirms that they represent the remains of Stelae Ridge as described by Engelbach. Although little clear Middle Kingdom structure could be identified in cairns 01–010, the flat faces and surviving remains of court structures to the east of cairns 011 and 012 suggest that these originally formed part of the group sketched by Engelbach, which he specifically mentions had stone lined courts against their flat eastern sides (Engelbach 1933, 68).

[184] Ian Shaw pers comm.

Despite the damage to the site, the Gebel el-Asr Project also found blank stelae (Fig 3.15) and two stone pyramidions (Shaw *et al.* 2010, 302), one of which was still visible around cairns 04-012 in 2012 (Fig 3.16). It has been identified as one of the ‘votive pyramids’ Engelbach (1933, 68) found at Stelae Ridge. The Gebel el-Asr Project also found an inscribed stela at cairn 013 (Shaw 2003, 453). Engelbach (1933, 69) states that ‘near the ancient excavation to the west of Stelae Ridge, are other cairns, some of which have provided stelae’. Cairn 013 fits Engelbach’s description being to the west of cairns 01-012 (Fig 3.14), between them and Mine 1.

Cairns 01–012 are therefore in the right place and are associated with the right types of artefact. The sheer number of cairns which must have stood in the area occupied by 01–012 on Fig 3.14 in order to provide the quantity of material still visible at the site, and the lack of any other areas near the mines where so many cairns, or their debris, are present, suggest that the features surveyed as cairns 01 to 012 represent the eight cairns, or their remains, recorded by Engelbach at Stelae Ridge.

While cairns 01–012 are collectively identified as the surviving remains of the eight Stelae Ridge cairns, the identification of individual cairns with the features recorded by Engelbach would contribute to understanding of the site, differentiation between surviving *in situ* Middle Kingdom cairns and more modern heaps of stones, and georeferencing of the Engelbach sketch plan.

Cairns 011 and 012

Today the pattern of ridges and cairns shown on Engelbach’s sketch plan is almost completely lost. Two of the cairns recorded in the 2012 survey at the north end of the northern ridge can be identified as original Middle Kingdom cairns. These two cairns were numbered 011 and 012 during the 2012 survey and are shown in blue on Fig 3.17. They are aligned north-south on a low ridge and are well constructed in dry stone, with flat eastern faces and traces of courts, outlined in stones, on their eastern sides. Their robust appearance suggested that they had been built with some care.

Based on their physical position in a north-south alignment, cairns 011 and 012 could be identified as Engelbach’s cairns II and III, VI and VII, or VII and VIII. Given that both cairns 011 and 012 display flat eastern sides and adjacent courts, it seems unlikely that they represent Engelbach cairns II and III, since Engelbach shows cairn III as rounded, without a flat eastern side or court. Furthermore, Engelbach shows cairns II and III at the southern end of the southern ridge with the other cairns mainly to their north. The amount of debris to the south of cairns 011 and 012 suggests that at least some of the remaining cairns were located to the south of them. It is therefore unlikely that cairns 011 and 012 represent Engelbach's cairns II and III.

If cairns 011 and 012 represent Engelbach's cairns VI and VII, cairn VIII would be expected to be north of them. The CORONA satellite image indicates that cairn VIII should be *c.* 7m north of VII, but the 2012 survey found no cairn and no debris in this location to the north of cairn 012. Therefore cairns 011 and 012 almost certainly represent Engelbach's cairns VII and VIII. This identification is supported by the relative size of cairns 011 and 012 and the distance between them, which is consistent with the dimensions of the two northernmost cairns on the CORONA image. There is *c.* 6m between cairns 011 and 012. Cairn 011 is *c.* 4.5m in diameter and cairn 012 is *c.* 7.2m in diameter, although they may originally have been bigger. The dimensions of cairns VII and VIII and the distance between them are slightly different in Engelbach's plan and in the CORONA image; cairn VII is *c.* 4.5m, cairn VIII is *c.* 5m in diameter and there is *c.* 8m between them in Engelbach's plan. On the CORONA image, cairn VII is *c.* 7m in diameter, cairn VIII is *c.* 9m in diameter and there is *c.* 4m between them. However, the resolution of the CORONA image, where a cairn is approximately 9 raster squares, makes precise measurement of the features impossible, while the Engelbach's plan is only a sketch and may not have accurately represented the precise diameter and location of the cairns. Allowing for these issues, the relative sizes and location of cairns 011 and 012 accord well with cairns VII and VIII in both Engelbach's plan and the CORONA image (Fig 3.17).

Cairn 06

Based on the presence of tyre and bucket marks from plant, their shape and their haphazard construction, cairns 04–010 were identified as the disturbed, disassembled and reworked remains of the original Middle Kingdom cairns to the south of cairns 011 and 012. Of this group only cairn 06 could potentially represent the remnants of an original Middle Kingdom feature. It was a more substantial feature than the others and, although it had been damaged by plant, appeared more robustly constructed. It was also precisely in the location where Engelbach's cairn VI should be found, *c.* 10m to the south of cairn 011. Cairn 06 is therefore a reasonable candidate for Engelbach's cairn VI (Fig 3.18).

The other cairns 04-05 and 07-010 are likely to be almost entirely the product of modern demolition, and comprise little more than the reworked ancient fabric, moved and piled up by modern machinery.

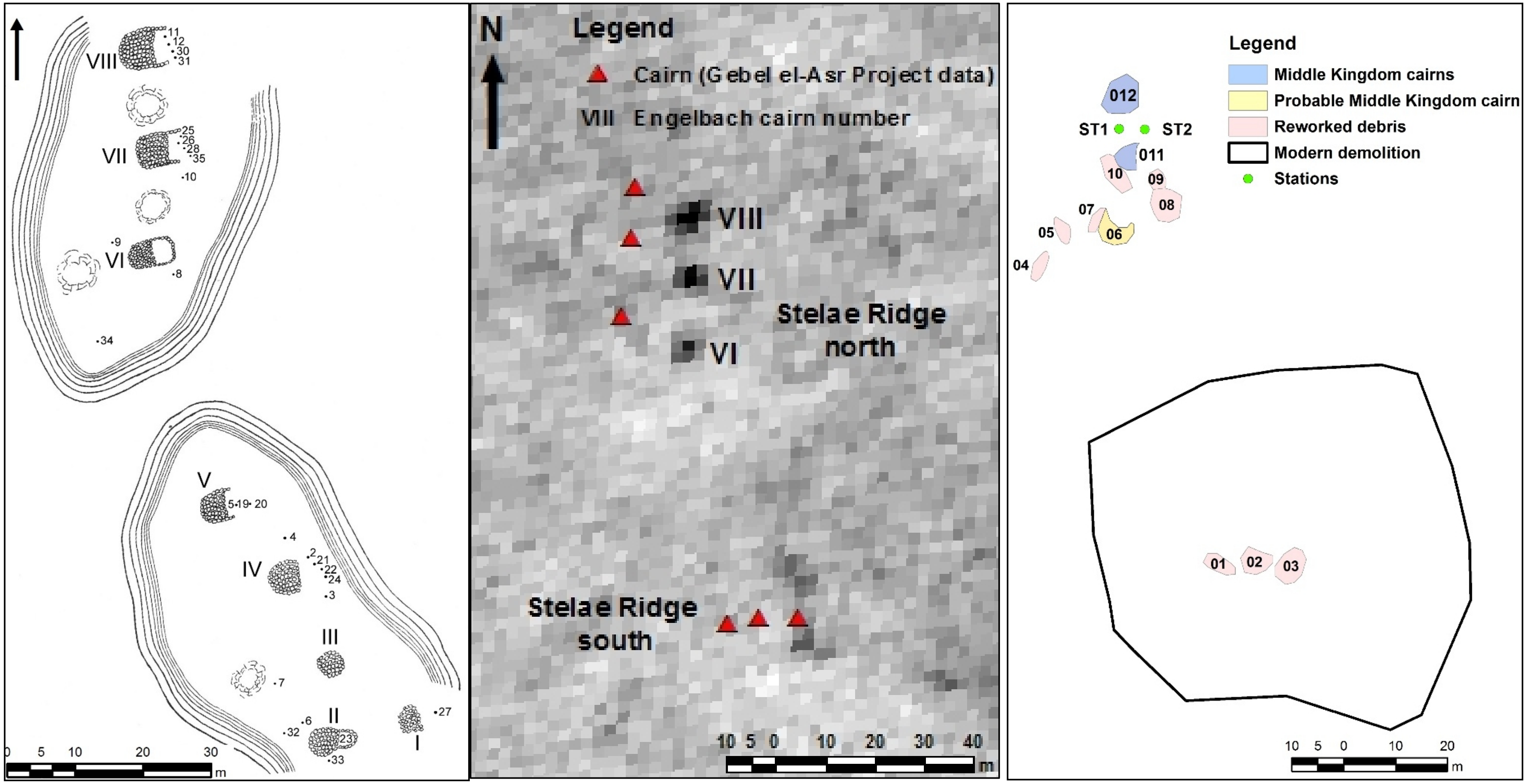


Fig 3.17: Comparison of Engelbach's sketch plan (left), Gebel el-Asr Project survey data overlying 1968 CORONA photograph of Stelae Ridge (centre) and 2012 survey data (right). (CORONA image 1105-2235DF077 1968 from CAST, University of Arkansas/USGS).

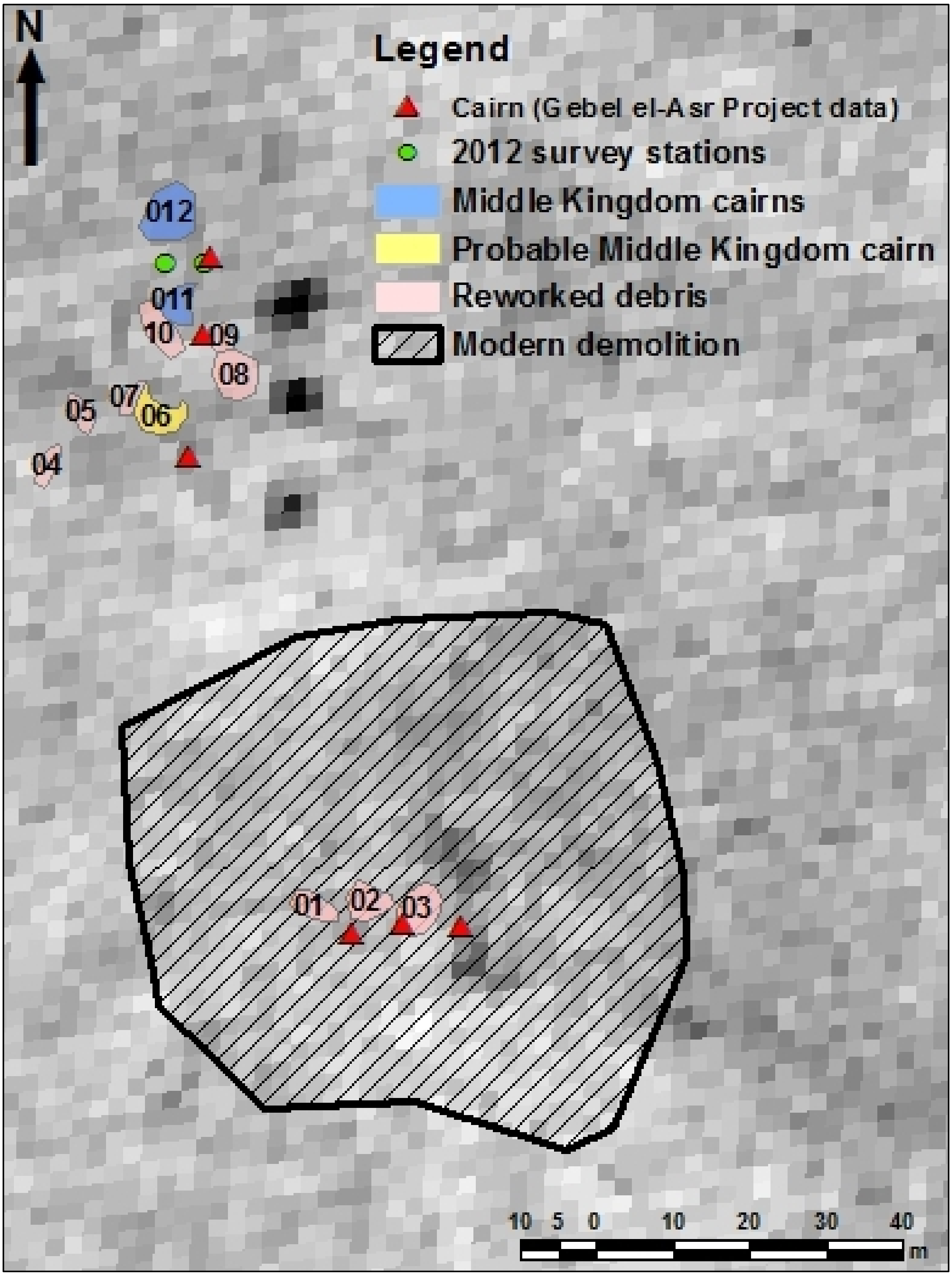


Fig 3.18: Gebel el-Asr Project survey data and 2012 survey of Stelae Ridge shown overlying the CORONA image. (CORONA image 1105-2235DF077 1968 from Centre for Advanced Spatial Technology, University of Arkansas/USGS)

Cairns 01–03

To the south of cairns 04 to 010 is a large polygonal area attesting to intensive modern activity. Visible on Landsat images from 1984 onwards and recorded by the Gebel el-Asr Project,[185] this area is marked by tyre tracks and scrape marks from JCBs. In the centre are three small cairns, numbered 01 to 03 (Fig 3.14 and Fig 3.18). Cairn number 01 has the distinctive sausage shape caused when material is scraped together and deposited by a JCB bucket. Although cairn 03 is more rounded and cairn 02 has a flatter northern side, there are clear tyre tracks and scars from JCB buckets around them and their stones are piled haphazardly together, without the care visible at cairns 011 and 012.

Engelbach's sketch plan shows the southernmost ridge of Stelae Ridge *c.* 37m south-east of the northern one. The CORONA imagery shows the same ridge *c.* 40m south-east of the northern one, although the individual cairns could not be clearly identified in the CORONA photograph. Based on these measurements, cairns 01-03 are located in the centre of the southern ridge where Engelbach shows cairn II and III and where a darker shadow in the CORONA image suggests there were cairns or the remains of cairns in 1968 (Fig 3.18). It is therefore probable that cairns 01 to 03 contain stones from some or all of Engelbach's cairns I to V, but they are not *in situ* and are not the same Middle Kingdom constructions recorded in the 1930s.

Other cairns

The 2012 survey recorded five other cairns in varying states of demolition across the Stelae Ridge area (Fig 3.19). The demolished remains of cairn 013 were located *c.* 100m to the west of Stelae Ridge. The cairn had been pushed over by plant, probably a JCB-type machine, and its stones heaped up haphazardly, although they are probably close to their original location. Cairn 013 has been identified as the remains of an unrecorded Middle Kingdom cairn on the basis of a Middle Kingdom stela dating to the reign of Amenemhat II found at the cairn by the Gebel el-Asr Project (Shaw 2003, 453). This cairn may have been mentioned by Engelbach (1933, 69) as one of those 'near the ancient excavation to the west of Stelae Ridge. . . which have provided stelae', although this description could equally apply to cairns 014–016 which are all closer to the large mine that has been identified as Engelbach's 'ancient excavation'.

[185] For the Landsat imagery Chapter 4 section 4.5.2. For the records made by the Gebel el-Asr Project see section 3.6.

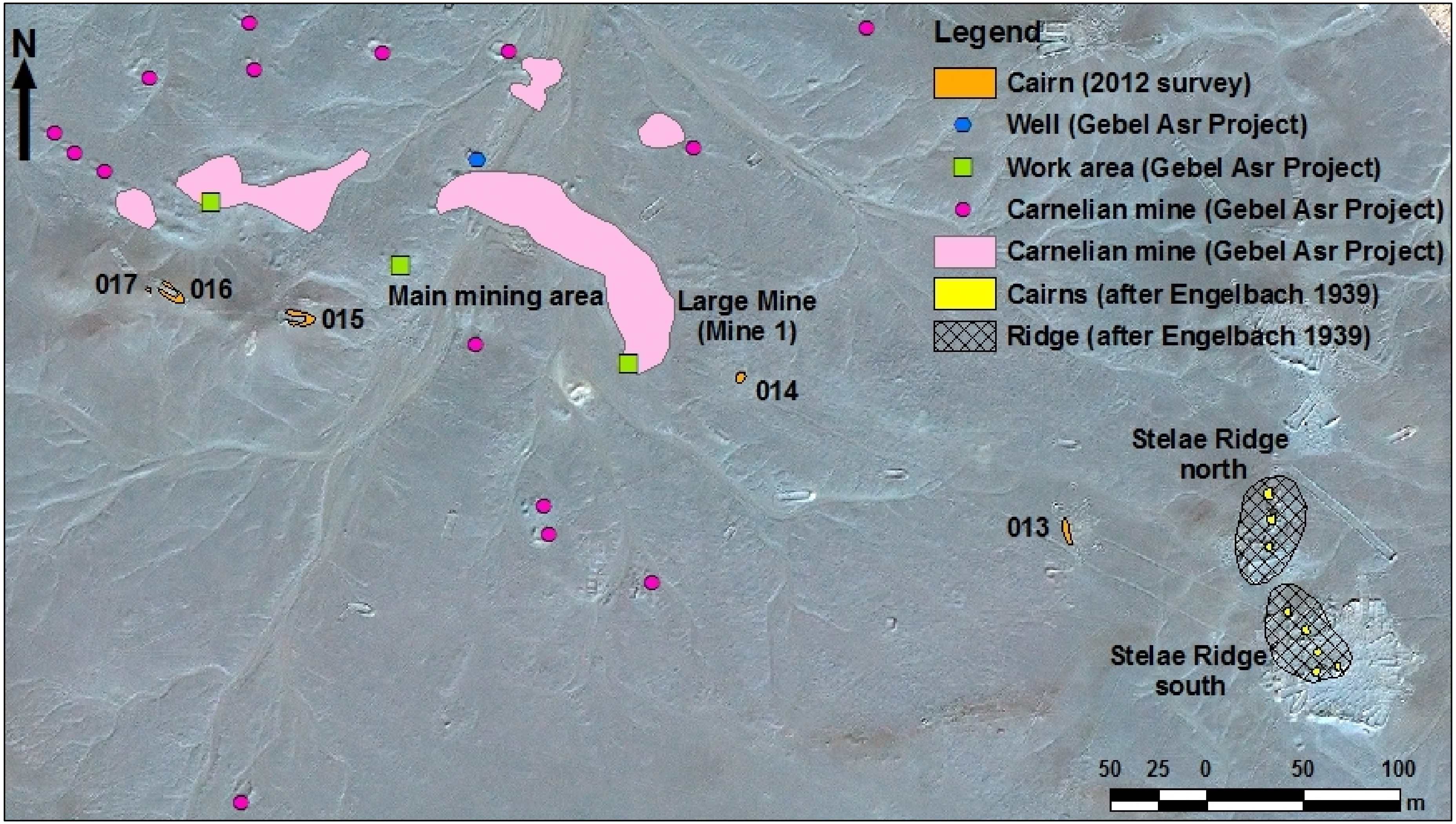


Fig 3.19: The five other cairns surveyed in 2012, with other archaeological features from the Gebel el-Asr Project data and Engelbach's plan overlying the Quickbird image used to transform the 2012 survey data. (Satellite image © European Space Imaging / Digitalglobe)

Cairn 014 and 017 were largely intact, although cairn 017 was extremely small and is probably a modern creation out of the remains of cairn 016. Cairns 014–016 had all been recorded by the Gebel el-Asr Project,[186] but since then cairns 015 and 016 had been pushed over by plant. The plant had turned the cairns into elongated ‘U’ shapes with a pile of stones at one end; this shape corresponds to the movement of the JCB bucket, which would push some of the stones aside as it moved through the cairn, before dumping them. Despite this, based on the Gebel el-Asr Project survey (Fig 3.9), the remains of cairns 015 and 016 are probably close to their original location.

At least one of cairns 014–016 is probably to be identified as cairn X which produced stela JE 59483 of Henenu, dating to the reign of Senusret I,[187] and was described as being ‘close to the workings north-west of Stelae Ridge (Engelbach 1939, 387)’. Cairns 015 and 016 are probably the best candidates for cairn X as they are very close to the large mine and, judging from their remains, were significantly larger than cairn 014 or 017. Cairns 014–017 might also have produced artefacts 13 to 18 in Engelbach’s list, which he numbered but did not describe and have since been lost. These artefacts were described as being ‘from outlying cairns which we have not been able to include in the maps (Engelbach 1939, 387)’.

3.7.3. Embodied experience of visibility at Stelae Ridge

The author chose to experience the site personally to provide an additional dimension to the visibility analysis and interpretation. Experimentation at other sites showed that personal experience provided useful information on visual range and insights into how the visibility analysis related to the practical experience.

Recording personal visual experiences is recognised as a difficult proposition.[188] Many researchers have opted for verbal description and photographs,[189] but these are difficult to repeat and are open to charges of selectivity.[190] To complement verbal description and individual photographs, photographic panorama and drawn ‘circular views’ were chosen to

---

[186] For the record of archaeological features at Stelae Ridge made by the Gebel el-Asr Project see section 3.6.
[187] The translation and date of this stela are provided in the unpublished manuscript kindly provided by Darnell and Manassa (2006).
[188] See the discussions in Brück (2005, 52) and Chadwick (2004, 21–22) concerning the difficulties associated with recording phenomenological investigations. Cummings (2000) discusses various options in more detail.
[189] See especially Bender *et al.* (1997); Cummings (2002, 2003); Thomas (2001; 2008); Tilly (1994).
[190] As has been pointed out by Fleming (1999; 2005; 2006); Hamilton *et al.* (2006); Renfrew (1994a).

provide a consistent and repeatable method of recording visibility as experienced at the site.[191]

General impression

The landscape gives the overall impression of flatness with a limited colour palette of greys to browns (Fig 3.20). This is relieved by occasional gebels, small hills of various heights that rise abruptly from the flat plain (Fig 3.21). Closer to Lake Nasser, these often have a conical appearance, but those visible from Stelae Ridge are flat-topped with steep sides.

Fig 3.20 Looking west from Stelae Ridge, with cairn 013 in the foreground. (Author photograph).

Fig 3.21: The Gebel el-Asr area, showing the generally flat landscape and local gebels. (Photograph courtesy of Ian Shaw)

The Gebel el-Asr is rather more rounded (Fig 3.22), as is a distinctive notched ridge to the south of Stelae Ridge. This ridge is the most distinct topographic feature closest to Stelae Ridge (Fig 3.23) and had previously attracted a number of cairns, although they were not

---

[191] For the use of photographic panorama see Cummings and Whittle (2004, 17–23). For circular views see Cummings (2002; 2003); Cummings and Whittle (2004, 17–23); Hamilton and Manley (2001); Hamilton *et al.* (2006, 42–43); Peterson (2003).

visible from Stelae Ridge (Fig 3.24). This ridge has been identified as Engelbach's (1939, 388) '20 cairn hill',[192] on the basis of the cairns located upon it and its dominance in the landscape when viewed from Stelae Ridge.

Fig 3.22: Gebel el-Asr, looking south towards the gebel from the nearby road. The disturbance in the foreground is associated with a Tushka Project canal that runs between the road and the gebel. A second, more distant gebel is visible to the left. (Author photograph).

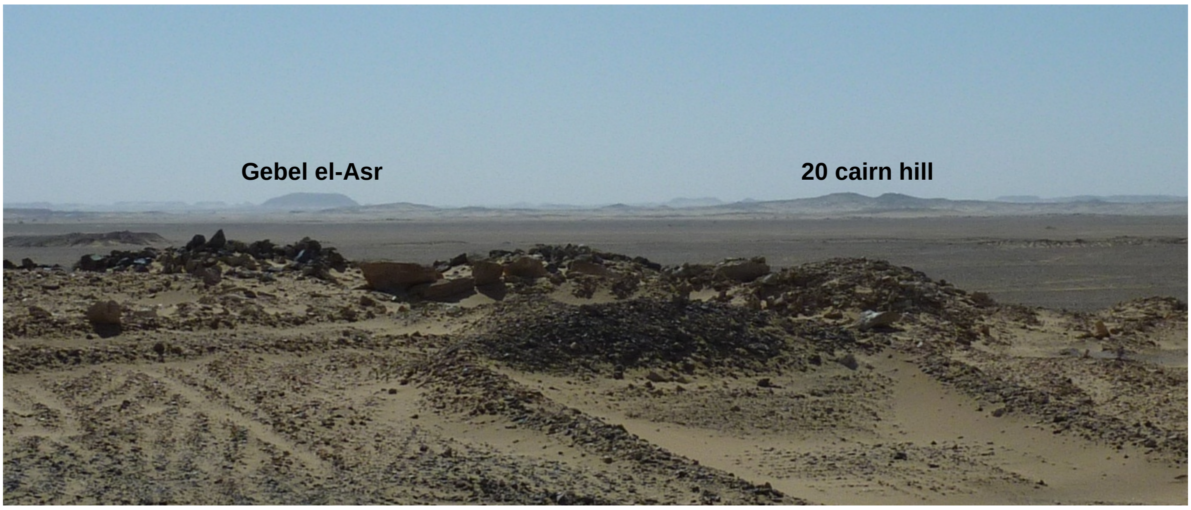


Fig 3.23: View south from Stelae Ridge showing Gebel el-Asr and the distinctive notched appearance of 20 cairn hill. The ridge in the foreground comprises the remains of the southern cairns of Stelae Ridge (Author photograph).

---

[192] See above section 3.3.2, for the ambiguity about this feature and its precise location.

Fig 3.24: 20 cairn hill, showing some surviving cairns. Taken from the Gebel Uweinat road, looking south-east. (Author photograph).

In such a flat landscape hills, and to a lesser extent cairns, stand out very clearly. Cairns on higher ground, like Stelae Ridge and 20 cairn hill, only serve to emphasise the topographic features (Fig 3.24). It is surprisingly comforting to recognise distinct landforms, particularly when they are occupied by cairns, in such a monochrome landscape. The presence of the cairns somehow reduces the experience of isolation and reminds a person that they are not alone in traversing an inhospitable landscape. This is consistent with the suggestion that such structures functioned as ‘place-makers’, humanising an otherwise inhospitable environment (Riemer and Förster 2013, 39–42; Darnell 2009).

From Stelae Ridge the most interesting landscape is to the south and east (Fig 3.22); the 180° to the north and west of the site are largely devoid of significant landforms. Given the relative comfort of the distant topographic features to the south, this gives the distinct impression that the landscape to the north and west is even more forbidding.

Photographic panorama

Photographic panorama create a record of the 360° or 180° view around a specific location as recorded by an individual. Two 360° panorama were taken from Stelae Ridge by Ian Shaw in 2011, and one 180° panorama was taken by the author in 2012 (Fig 3.25). These panorama are presented below. The author is 1.64m tall and Ian Shaw is 1.78m tall. All panoramas were taken without a tripod using commercially available digital cameras made by Panasonic. The panorama are composed of a number of overlapping photographs joined together using Adobe Photoshop Elements 11. Each 360° panorama is presented divided

Fig 3.25: Locations of the panorama taken by the author in 2012 and Dr Ian Shaw in 2011. Image made using ArcGIS 10, using data from Digitalglobe. (Satellite image © European Space Imaging/ Digitalglobe)

into four separate images, corresponding to the north-eastern, south-eastern, south-western and north-western quadrants of the view. Key topographic and archaeological features are labelled, and cardinal points are indicated by initials.

The first panorama (Fig 3.26) was taken in 2012 by the author from a location east of cairn 06 and shows 180° of the view on the eastern side of the Stelae Ridge cairns. This panorama covers the most topographically interesting parts of the landscape around Stelae Ridge.

The second panorama (Fig 3.27) was taken in 2011 by Ian Shaw from a location south-west of cairn 06. Comparison with Fig 3.26 reveals that visibility was lower on the day the second panorama was taken; distant features do not appear as clearly on Fig 3.26 and the sky appears hazier. The third panorama (Fig 3.28) was taken in 2011 by Ian Shaw from the southern part of Stelae Ridge at a location north of cairn 03.

Fig 3.26: Panorama 1, 180° from north to south taken in 2012 by the author from east of cairn 06 at Stelae Ridge. The panorama was made from four digital photos using the photomerge function of Adobe Photoshop Elements 11. The contrast has been enhanced to make the features easier to identify, and major landforms and structures are labelled. The minibus in the first half of the panorama is standing on the Gebel Uweinat road.

Fig 3.27a: Panorama 2, 180° from north to south from west of cairn 06 at Stelae Ridge. Note the lower visibility compared to Panorama 1. The panorama was made by the author using Adobe Photoshop Elements 11 and five digital photos taken in 2011 by Ian Shaw.

Fig 3.27b: Panorama 2, 180° from south to north from west of cairn 06 at Stelae Ridge. Cairn 012 is just visible, cairn 013 is almost directly west of Stelae Ridge and modern buildings are visible on the horizon. Beyond cairn 013 is the large carnelian mine, but this is not visible as a topographic feature. The panorama was made by the author using Adobe Photoshop Elements 11 and five digital photos taken in 2011 by Ian Shaw.

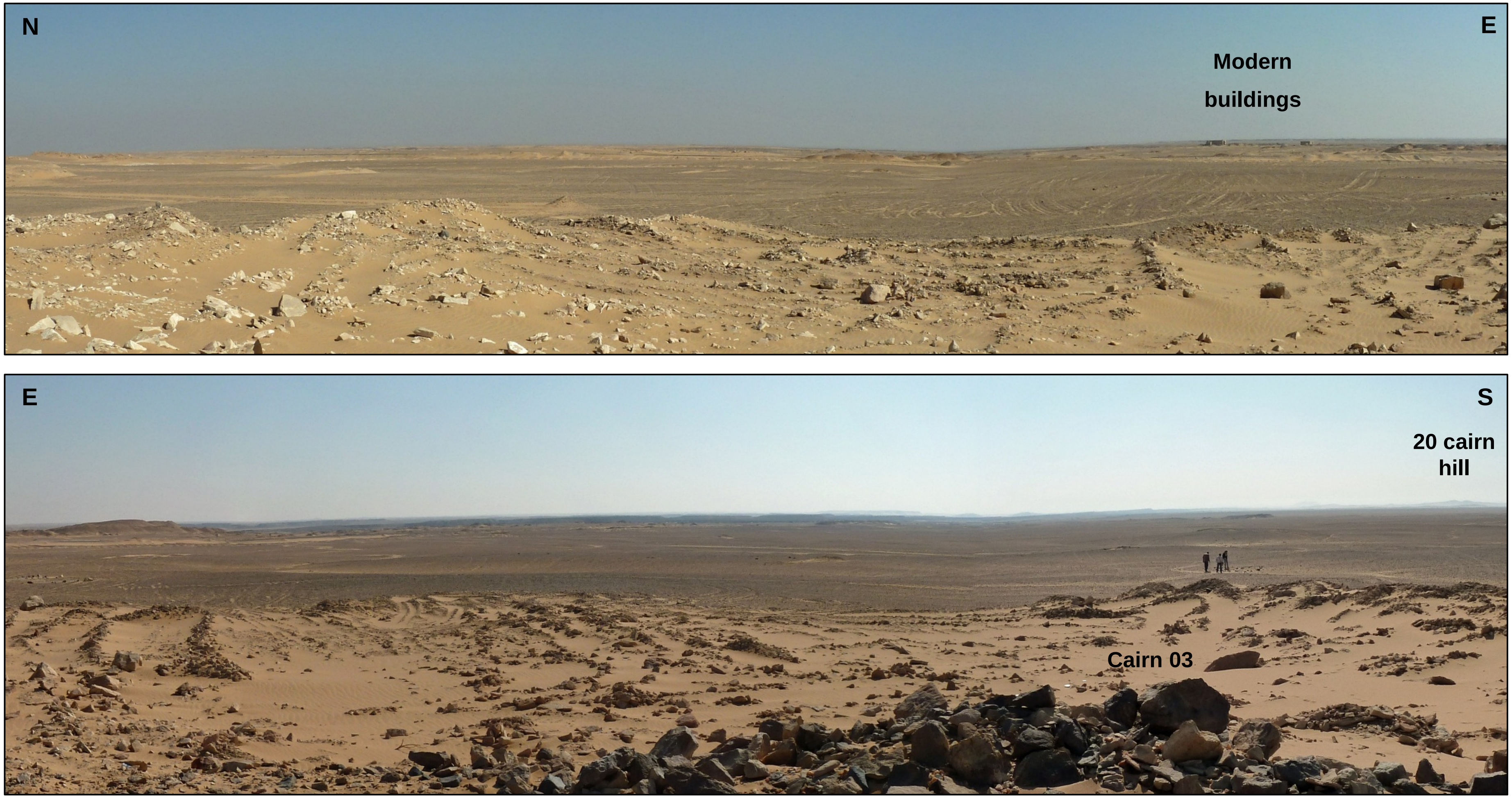


Fig 3.28a: Panorama 3, 180° from north to south from the north of cairn 03 at Stelae Ridge The landscape is hazy and visibility is not as good as in Panorama 1, 20 cairn hill is just visible, but the Gebel el-Asr is not. Cairn 03 is in the foreground. The panorama was made by the author using Adobe Photoshop Elements 11 and five digital photos taken in 2011 by Ian Shaw.

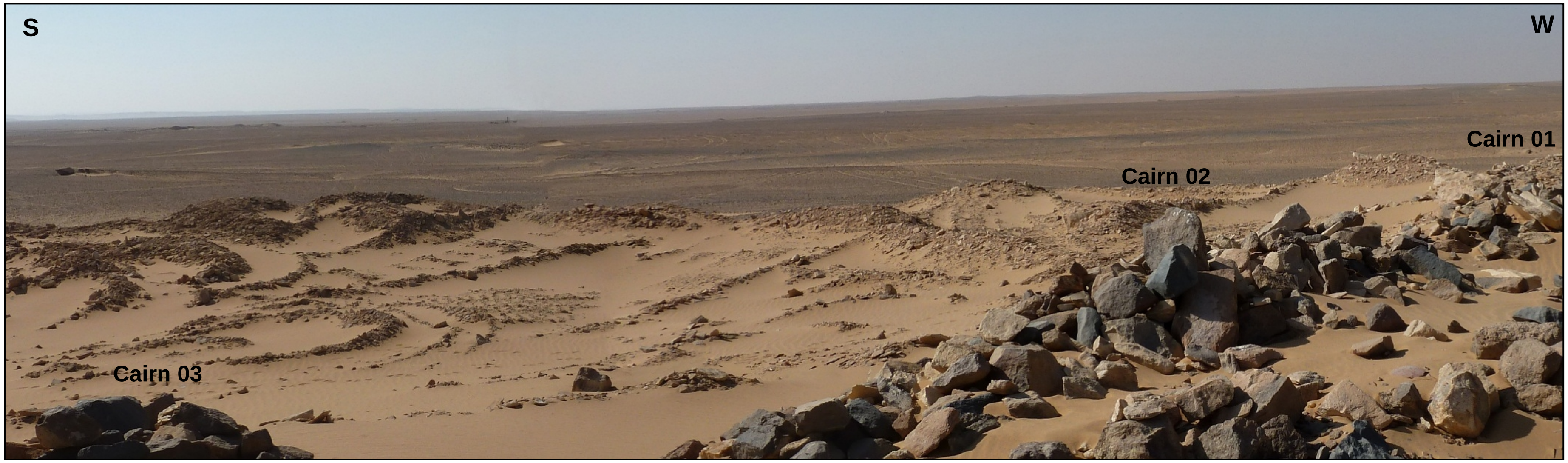


Fig 3.28b: Panorama 3, 180° from south to north from the north of cairn 03 at Stelae Ridge. Cairns 06, 011 and 012 are visible in the middle ground. The panorama was made by the author using Adobe Photoshop Elements 11 and five digital photos taken in 2011 by Ian Shaw.

The panoramas convey the flatness of the terrain around Stelae Ridge and reveal how prominent the Stelae Ridge cairns appear in such a landscape. Apart from the cairns themselves, the most prominent topographic features are 20 cairn hill and the Gebel el-Asr in the distance. Comparison of Panorama 1 and Panoramas 2 and 3 confirms the impact of haze or low visibility, which could easily render substantial topographic features invisible. In Panorama 1 both Gebel el-Asr and 20 cairn hill are distant but distinct, but in Panoramas 2 and 3 even 20 cairn hill is difficult to see, reflecting the increased haze and decreased visibility.

Circular view

An adapted form of Hamilton *et al.'*s (2006, 42–43) 'circular view' was also employed to record visual experience, but had to be adapted to the requirements of Stelae Ridge. As Stelae Ridge is very flat only three concentric circles were necessary, representing the near, middle and far horizons respectively. Features drawn on those horizons were located by bearing, but some flexibility was permitted in the precise size and shape of the features to ensure the circular view conveyed the correct impression of the landscape experienced by the author. It should also be noted that the circles represent the perceived horizon and do not bear any relation to the precise distance of the features from the observer.

Due to the limited time on the site, a single record of the circular view was taken from the same location as the author's panorama (Fig 3.25). However, it could be repeated in future by other researchers for verification or, as suggested by Hamilton *et al.* (2006, 43), to gain an understanding of how different individuals might perceive the site. The resulting circular view is presented in Fig 3.29.

Fig 3.30 is an amalgam of the two northern panoramas (Panorama 1 and Panorama 2), labelled with features present on the circular view for ease of identification. It should be noted that only Panorama 1 was taken from the same location as the circular view. Named features, cairns, modern buildings, damage and spoil heaps are labelled as such. All other topographic features are labelled G1 (Gebel 1) to G8.

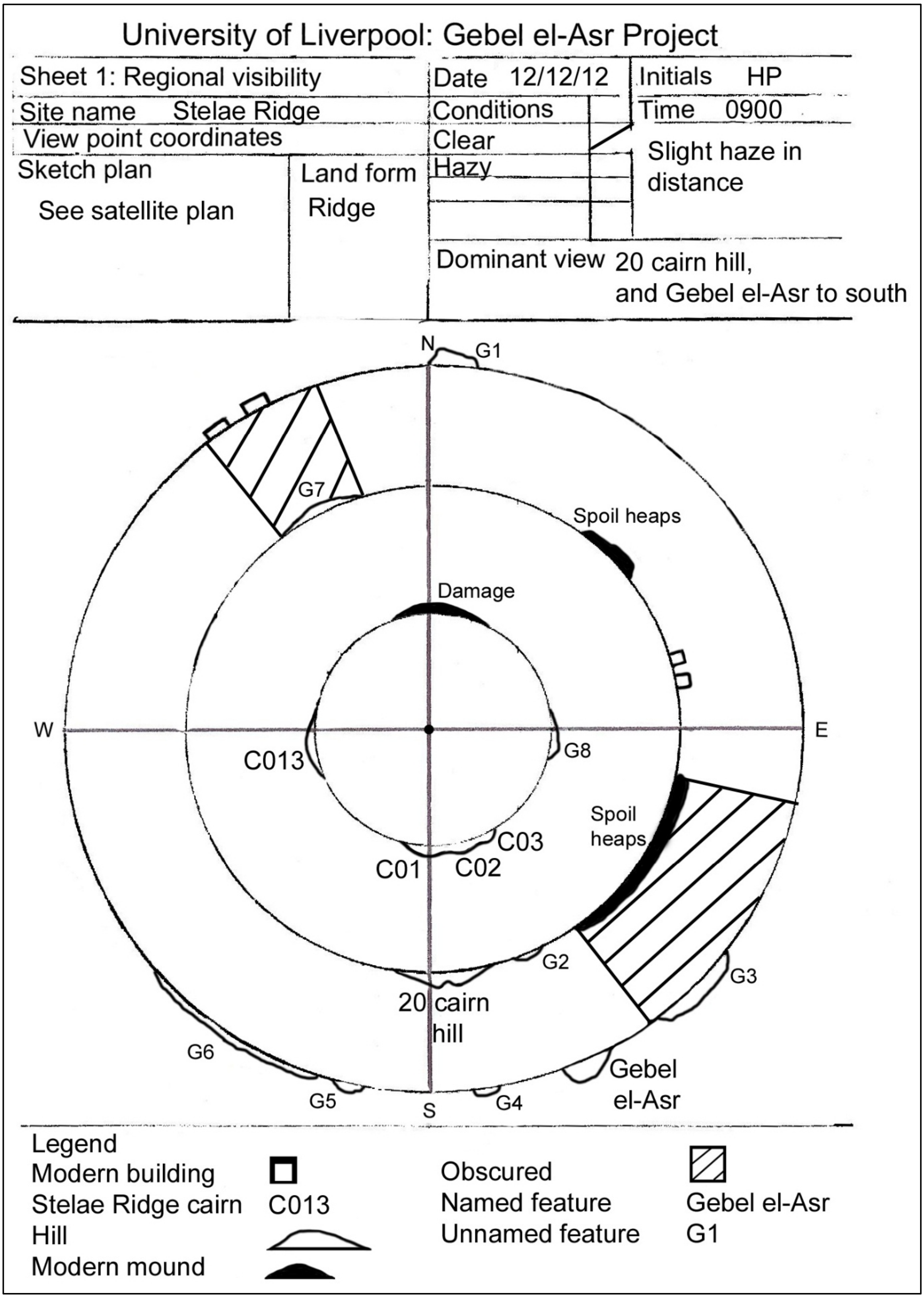


Fig 3.29: The circular view from Stelae Ridge. Compare with panoramas in Fig 3.30. Based on an original created at the site by the author and digitised in Adobe Photoshop Elements 11.

Fig 3.30a: Panorama showing the features recorded on the circular view (Fig 3.29). The panorama from north to east was generated from photos taken by Ian Shaw in 2011. The panorama from east to south was generated from photos taken by the author in 2012. The panorama were made by the author in Adobe Photoshop Elements 11.

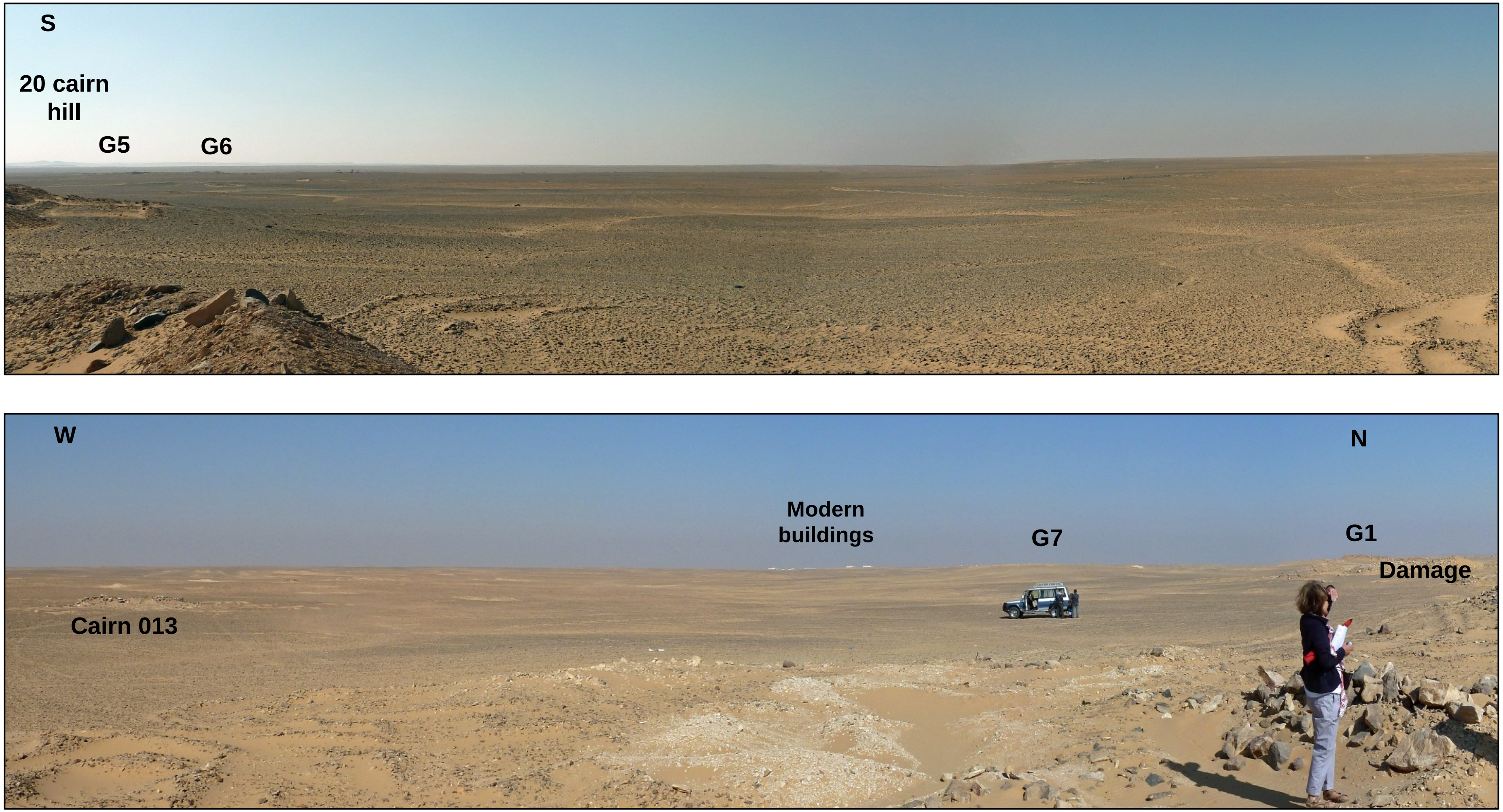


Fig 3.30b: Second half of the panorama showing the features recorded in the circular view. This panorama was generated in Adobe Photoshop Elements 11 from photos taken by Ian Shaw in 2011.

Some distant features do not appear as distinctly in Fig 3.30 as they did to the author when the circular view was recorded. This is partly because the circular view was taken on a clearer day than Panorama 2, but it also reflects the different locations and the limitations of camera resolution in recording very distant features which are not distinctive in terms of their colour. Although the record of the landscape around Stelae Ridge is generally consistent across both the panoramas and the circular view, the indistinct appearance of the distant gebels in the photos makes the circular view an important record of what was seen from the site.

Overall, the circular view confirms earlier comments about the general flatness of the terrain, particularly the northern 180° around Stelae Ridge. To the south, the Gebel el-Asr and 20 cairn hill appear as the dominating physical features and to the east G8 and G3 are quite prominent although quite distant.

The circular view did reveal one problem with the identification of the notched ridge as 20 cairn hill. The notched ridge is located at a bearing of *c.* 160° from Stelae Ridge, but Engelbach (1933, 69; 1939, 388) identified ’20 cairn hill’ as being 144° from Stelae Ridge, on the bearing between it and Tushka. Examination of satellite images revealed that the notched ridge was 5.8km from Stelae Ridge,[193] when Engelbach claimed 20 cairn hill was 5.2km from Stelae Ridge. However, there was no topographic feature at the right distance from Stelae Ridge on the bearing given by Engelbach, which was both sufficiently distinct and dominant in the landscape to be identified as 20 cairn hill. Although G2 was on roughly the right bearing, it was slightly too far away, was quite small and did not appear very distinctly in any of the panorama, certainly not compared with the notched ridge. G3 was certainly large enough, but was too far away at 6.5km from Stelae Ridge and panorama 2 and 3 show that it would not have been visible, except under the best atmospheric conditions. The notched ridge will therefore be identified as ’20 cairn hill’ unless or until subsequent research reveals further information that may resolve the uncertainty.

Experience of visual range at Stelae Ridge

The circular view and panoramas also provide useful information concerning visual range at Stelae Ridge. Visual range is the distance it is possible to see, given the physical effects of atmospheric extinction and the curvature of the earth upon visibility. Theoretical aspects of visual range are considered in Chapter 2 section 2.7.3.

---

[193] For the satellite imagery see Chapter 4, section 4.5.

By locating the landmarks recorded in the panoramas and circular view on satellite imagery in the GIS,[194] it is possible to determine current visual range from the Stelae Ridge cairns (Fig 3.31). Of all the topographic features, 20 cairn hill was most consistently and reliably visible across the different panorama. The Gebel el-Asr and the long flat-topped gebel on the other side of the main canal, labelled G3 on the panorama and circular view, were also reasonably visible under good conditions. The very distant features, such as G4 and G5, are much less distinct and would only be visible to someone with very good vision on the clearest of days. Overall experience of visual range at the site indicates that the Gebel el-Asr represents about the limit of reasonable visibility, although slightly more distant features might have been visible to the far-sighted or under very good atmospheric conditions.

The Gebel el-Asr is 11.5km, 20 cairn hill is 5.8km and G3 is 6.5km south-east of ST1. The distant topographic features are more difficult to identify on the satellite imagery because their shape is indistinct. There are a number of gebels to the south of Gebel el-Asr and 20 cairn hill which could represent G4 and G5, but at most they extend the visible range by a few kilometres, and then only on the clearest days. Based on the experience of visibility at Stelae Ridge, current visual range extends to the Gebel el-Asr at about 11.5km from the site, and maximum visual range is slightly further under very good conditions. Within that range, more distant features will inevitably be less visible under poor conditions or to individuals with less than normal vision. Nearer features, like 20 cairn hill, comprise the immediate visual context of the site and are likely to be visible under all but the worst conditions.

Overall, the experience of visibility at the site is broadly consistent with the 9.2–12.67km theoretical visual range calculated in Chapter 2, section 2.7.2 on the basis of the aerosol extinction coefficient data obtained by Husar *et al.* (2000, 5073) for this part of the Sahara, allowing for slightly increased visibility due to pre-industrial levels of pollution and slightly more hospitable climatic conditions. To allow a margin above normal visible range and reflect that some features beyond the Gebel el-Asr were just visible under very good conditions, the maximum visual range for the visibility analysis was set at 15km.

[194] Landsat 8,15m resolution panchromatic band satellite imagery was used because it provided the best resolution. For the details and technical specifications of this imagery see Chapter 2, section 2.2.2 and for other Landsat imagery see Chapter 4, section 4.5.2.

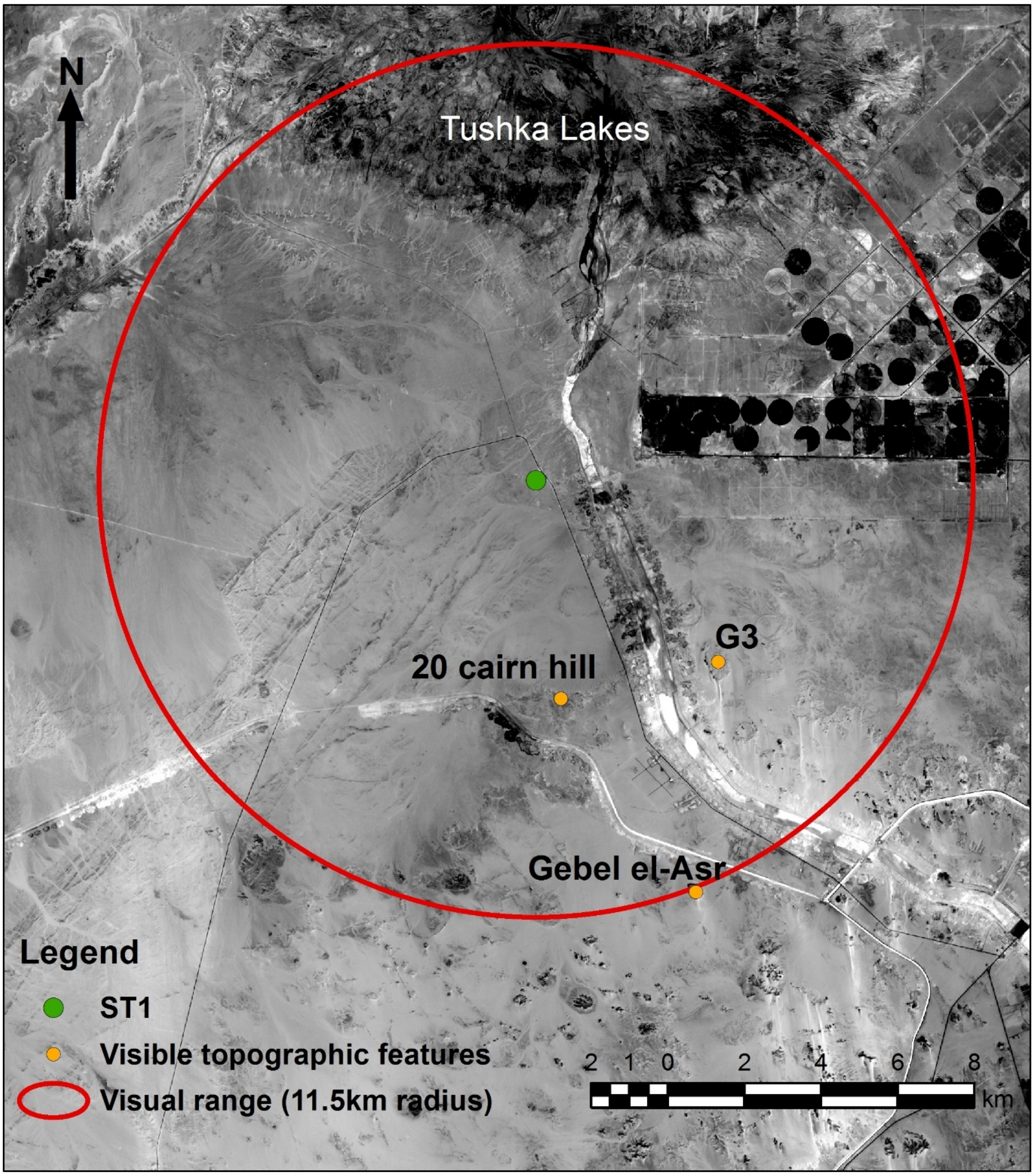


Fig 3.31: Landsat 8,15m resolution image of the Gebel el-Asr region from 2013, showing the location of identifiable topographic features recorded in the circular view and panoramas. The red circle delimits an area 11.5km radius from ST1. Note the number of small gebels and ridges to the south of Gebel el-Asr and 20 cairn hill. Any of these could be the unknown topographic features G4 and G5, although those closest to the 11.5km radius buffer are the most likely candidates. (Landsat Image LC81750442013144LGN00 available from the USGS).

The key landforms visible from Stelae Ridge provide a good indication of the maximum visual range. However, it is also worth considering the relative visibility of the flat areas around Stelae Ridge and between the higher hills and topographic prominences. In general a person at Stelae Ridge has good views over the area around it and, with some localised variability, as far as 20 cairn hill 5.8km to the south. To the north, the view is more restricted, and the northern plain is much less visible except from the northern end of Stelae Ridge, which has a commensurately less extensive view of the plain to the south. Beyond 20 cairn hill it is impossible to see any extensive area of plain and only hills and ridges are recognisable.

This is significant because in Chapter 2, section 2.7.1 viewsheds produced by both ArcGIS 10.1 and GRASS 7.0 GIS programmes suggested that several areas would be visible from Stelae Ridge, even though they were much further distant from Stelae Ridge than the 5.8km between it and 20 cairn hill. In reality only very specific topographic features can be discerned over these distances, rather than substantial areas of desert plain. Because of this the ArcGIS viewshed was considered likely to be more realistic, as it was smaller and included fewer of these distant areas.

3.8. Geolocational differences between the sources.

Inherent geolocational errors affect the Gebel el-Asr Project GPS data, all the satellite imagery and, because it was transformed onto UTM 36N coordinates using the Quickbird imagery, the 2012 survey data. The Gebel el-Asr Project data was understood to be accurate to *c.* 5m (Bloxam 2003b, 37). Where possible the accuracy, known error and resolution of the satellite images have been discussed in Chapter 2, sections 2.2.1–2.2.3, but the data presented reflects measures of accuracy and error across entire satellite image datasets. The accuracy of individual images of Stelae Ridge may be different from those of the global or continental dataset as a whole.

The inherent inaccuracies in the geographical positioning of the Gebel el-Asr Project survey data and the satellite images pose problems relating the different sources of data to each other in the GIS. The various different errors have produced differences in the location of the Stelae Ridge features as determined by the CORONA photographs, the Gebel el-Asr Project survey data and the Quickbird imagery/ 2012 survey data. Following orthorectification with the SRTM, the CORONA imagery shows Stelae Ridge *c.* 12m south-east of the location given by the Gebel el-Asr Project GPS (Fig 3.10) and *c.* 20m south-east of the location given by the Quickbird satellite imagery/ 2012 survey data (Fig 3.32). The Gebel el-Asr Project differential GPS survey locates the Stelae Ridge cairns *c.* 8m south-east of the location given by the Quickbird image/2012 survey data and *c.* 12m north-west of their location on the CORONA image (Fig 3.32). The specific error attributable to each individual image or dataset is not currently known, although the difference of *c.* 12–20m between the CORONA data and the other sources is well within the error range of *c.* 50–80m given by Casana *et al.* (2012) for rectified CORONA imagery. It may also be significant that the 8m difference between the Gebel el-Asr Project GPS survey data and the Quickbird image is the same as the error found using a differential GPS with a navigated RTK solution at Dra Abu l'Naga.[195] This could suggest that the Quickbird image, and by extension the 2012 survey data, represents the most accurate dataset and gives the most accurate location for Stelae Ridge. At any event, a maximum distance of *c.* 20m between the three sets of data is a positive result considering the sources and their known or probable levels of precision and accuracy.

3.9. Georeferencing Engelbach's maps

All of Engelbach's maps and plans needed to be georeferenced so they appeared in the correct location on the UTM 36N coordinate system, could be compared with the satellite images and Gebel el-Asr Project and 2012 survey data, and could provide observer and target locations for the visibility analysis.

3.9.1. Sketch plan of the Stelae Ridge cairn-courts

The sketch plan of the cairns at Stelae Ridge (Fig 3.1) was most difficult to georeference. The damage to the site since Engelbach recorded it makes it difficult to relate the sketch to the surviving remains visible in the Gebel el-Asr Project survey data or the Quickbird satellite image, and precludes the identification of sufficient common control points. The CORONA image probably shows the site in a similar condition to that described by Engelbach, but is not high enough resolution for sufficient control points to be identified to permit reliable georeferencing.

The more detailed survey undertaken in 2012, provides additional information about the layout of the surviving cairns. Once Engelbach's cairns VI, VII and VIII had been identified, the 2012 survey data offered the most detailed description of the layout of these structures since Engelbach's sketch and provided a new opportunity to locate reliable control points with UTM 36N coordinates.

---

[195] See research into the error associated with of different types of post-processing for differential GPS coordinates, undertaken at Dra Abu l'Naga south by Jones and Pethen (In prep).

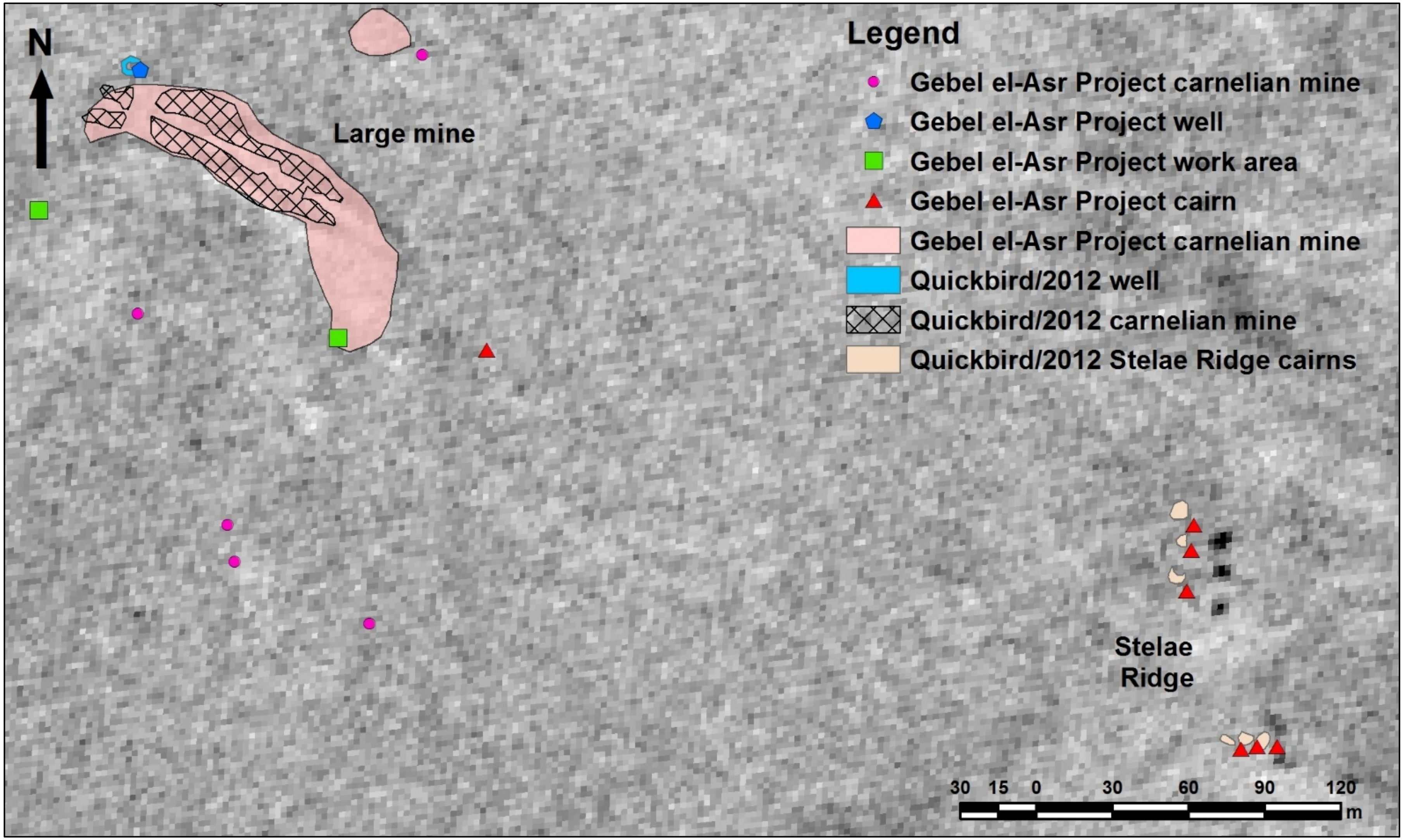


Fig 3.32: Geolocational differences in the position of Stelae Ridge between the 1968 CORONA photograph (DS1105-2235DF077), Gebel el-Asr project data and Quickbird satellite image/ 2012 survey data. (CORONA image from CAST, University of Arkansas/USGS).

Georeferencing Engelbach's sketch plan of Stelae Ridge using the 2012 survey data revealed that the scale of the sketch is approximately 1:450. Although a number of control points could be identified around the northern cairns, they were too poorly collimated to be viable.[196] It was not possible to create a more balanced distribution of control points, because the damage to the southern part of the site prior to the 2012 survey had removed many of the cairns shown on the sketch. Despite this, the better detail in the 2012 survey data makes it more suitable for georeferencing the sketch plan of Stelae Ridge than the CORONA imagery, which also only clearly shows the northern cairns, but at a much lower resolution.[197] In the absence of any better source of control points, the sketch of Stelae Ridge had to be georeferenced using the 2012 survey data and a 'best fit' approach without control points or an RMSE (Fig 3.33).

Although the resulting rectified sketch plan of Stelae Ridge was the best that could be achieved given the available resources, there are still inaccuracies in it. For example, the flat faces of cairns 011 and 012 in the survey data should align with the faces of cairns VII and VIII in Engelbach's sketch. Cairn 011 and VII align very well, but the face of surveyed cairn 012 is *c.* 2m east of the face of Engelbach cairn VIII (Fig 3.33). Without additional control points, shifting the sketch so that the faces of surveyed cairn 012 and Engelbach cairn VIII aligned with each other meant that cairn VII shifted out of alignment with surveyed cairn 011, cairn VI shifted out of any relationship with surveyed cairn 06 and the Engelbach cairns on the southern ridge appeared in a much less probable location.

Despite these problems, given the extent of the damage to the site, the fit between the georeferenced plan of the Stelae Ridge cairns and the 2012 survey of them is surprisingly good. Engelbach's sketch plan is the only record of the original layout of the site, and georeferencing it was essential to creating the observer locations for the visibility analysis of the eight Stelae Ridge cairns. Without this plan there would be no record of the layout of the cairns on the southern ridge and no opportunity to identify the observer locations discussed in Chapter 2, section 2.5.

---

[196] During georeferencing the control points must be well distributed around the image, or poor collimation can cause inappropriate warping of the raster.
[197] A previous attempt had been made to georeference the sketch plan using the CORONA image. This attempt also failed to identify sufficient well-collimated control points and had to resort to a 'best-fit' approach.

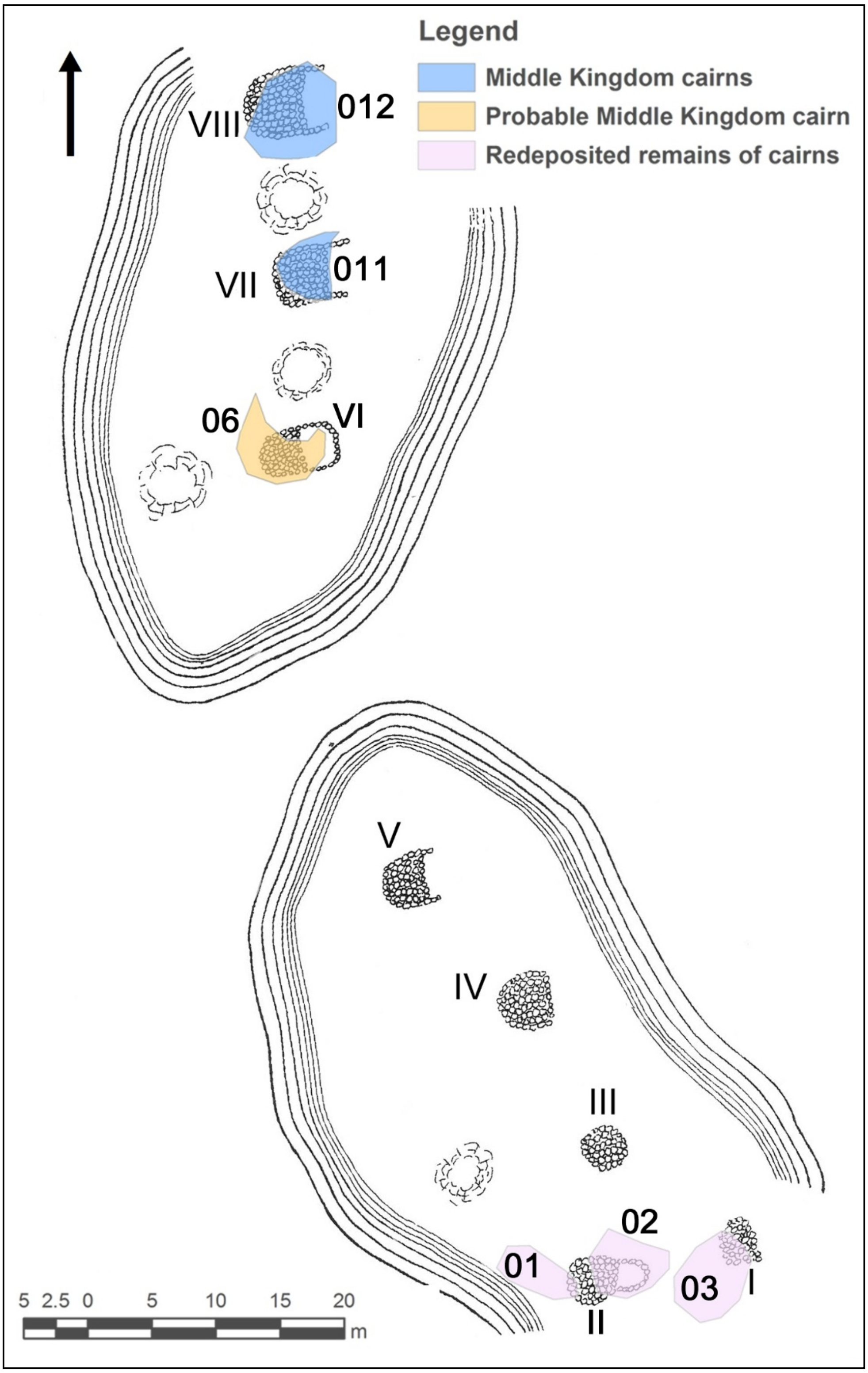


Fig 3.33: Results of the 2012 survey overlaid on the georeferenced Engelbach plan to show the relationship between the known and probable Middle Kingdom cairns and those sketched by Engelbach. Roman numerals indicate cairn numbers assigned by Engelbach, Arabic numerals indicate 2012 survey numbers.

3.9.2. Small scale map of the Gebel el-Asr region

Engelbach's 1:500,000 scale plan of the Gebel el-Asr area (Fig 3.2) was based on the Survey of Egypt's 1:500,000 scale map of the Aswan region. Since a georeferenced copy of the 1944 Survey of Egypt 1:500,000 scale map of the Aswan region was obtained from the Centre for Ancient Middle Eastern Landscapes (CAMEL) of the Oriental Institute, Chicago, it was used to georeference the Engelbach version.[198] The RMSE of the rectified Engelbach plan was 26.29496m. Error of less than 1:3000m is generally considered acceptable (Conolly and Lake 2006, 83) and this RMSE of 26.29m therefore falls well within the acceptable limit of 166.66m for a map of this scale.

3.9.3. Map of the Gebel el-Asr quarries

The 1:100,000 scale sketch plan of the Gebel el-Asr quarrying area (Fig 3.3) was also based on the Survey of Egypt 1:500,000 scale provisional map of Aswan, but it only included one reference point with known geographic coordinates. Stelae Ridge, Khufu Stela and Quartz Ridge were all shown on the sketch plan and, because their UTM 36N coordinates were included in the Gebel el-Asr Project data, they were chosen as the other three control points. When the georeferencing was undertaken using these four control points, the rectified image had a RMSE of 56.42606m. This is slightly higher than the preferred error of less than 1:3000m (or 33.33m for an image of this scale), but it was not possible to find any other control points.

3.10. Conclusion

Analysis of multiple sources of evidence, including a new archaeological survey undertaken in 2012 specifically for this project, has reduced the impact of the limitations of the published record of historical research and the recent damage to the site. Evidence from archaeological excavation and survey, satellite imagery and GIS research provides the archaeological, historical, chronological and landscape context for the visibility analysis and subsequent interpretation of the structures at Stelae Ridge.

Together with evidence from other sources, research at the site in 2012 confirmed the location of Stelae Ridge, permitted the identification of the surviving cairns and produced a more accurate georeferencing of Engelbach's sketch plan of the Stelae Ridge structures. This is crucial to the success of the research because, with the modern damage to the site,

---

[198] The 1944 Survey of Egypt 1:500,000 scale map of Aswan is shown in Chapter 4, section 4.4.2, Fig 4.9.

Engelbach’s sketch plan is the only record of the layout of the Middle Kingdom cairn-courts and therefore the only source which can provide observer locations for the visibility analysis. The visit to the site also enabled the author to gain insights into the landscape and the experience of visibility within it, providing practical experience of visual range and the local landforms to inform and balance the GIS visibility analysis.

4. Digital elevation model, climate and landscape

This chapter considers the digital elevation model (DEM), which represents the topography of the site and surrounding landscape in the visibility analysis. It assesses the sensitivity of the DEM and how far it conforms to the likely Middle Kingdom landscape, present when the Stelae Ridge cairns were constructed and used.

4.1. Sources of digital elevation models

DEM may be custom-generated by researchers for specific projects or obtained from national or international providers. Whatever their source the generation of all DEM involves the interpolation of topographic data by a GIS or similar software. The topographic data may come from a variety of sources and different interpolation algorithms may be used.[199]

DEM are typically interpolated from LiDAR data,[200] contour maps,[201] topographic survey data or satellite imagery. LiDAR data and large scale contour maps of the Gebel el-Asr area are not available because the site is located in a militarily sensitive area. The existing small-scale contour maps of the Gebel el-Asr region are not sufficiently detailed to be used for DEM interpolation.

Topographic survey provides an alternative to generating DEMs from contours or remotely sensed data. It involves making a record of the coordinates and heights of individual locations at regular intervals, to create a 'point cloud' which can be interpolated by a GIS to produce a model of the landscape from which the points were derived.[202]

Topographic survey provides great flexibility, as the surveyor can tailor the extent, method and intervals between survey points to the most appropriate resolution and interpolation method for his or her research. However, issues of the time, access and cost also need to be taken into consideration. The necessity of obtaining direct access to the survey area, the

[199] See Chapman (2006, 72–77); Conolly and Lake (2006, 90–111); Hagemann and Bennett (2000) for an overview of DEM creation. For Inverse Distance Weighting techniques (IDW) see Burrough and McDonnell (1998, 117–119). For Splines see Burrough (1986). For Kriging see Burrough and McDonnell (1998, 132–151); Haining (2003, 325–333); Lloyd and Atkinson (2004). For Triangulated Irregular Networks (TIN) see Chapman (2006, 72–74); Goucher (1997, 249–50); and Voigtmann *et al.* (1997).

[200] For LiDAR-based DEM see Chapman (2006, 58) and Conolly and Lake (2006, 72, 305) for an overview and DeLoach and Leonard (2000); and Brock *et al.* (2002) for specific applications.

[201] For DEM derived from contour maps see Burrough and McDonald (1998); Carrara *et al.* (1997); Conolly and Lake (2006, 103–111); Franklin (2000); Merwin (*et al.* 2002); and Yang and Hodder (2000).

[202] Chapman (2006, 61–64) gives an overview of the implications of collecting topographical survey data for DEM generation

cost of hiring or purchasing the equipment[203] and the need to undertake physical collection of the survey points make extensive topographic survey expensive, particularly in Egypt where permission must also be obtained to work at specific sites and survey teams must be flown to the country and fed and housed during the process. It would be prohibitively expensive to undertake topographic survey of the entire visible landscape around Stelae Ridge, since the landscape is largely flat and it is possible to see for many kilometres.

4.2. Satellite-derived digital elevation models

Stereo-pair satellite images can be used to create DEMs of large areas without the necessity of travelling to the survey region,[204] but this requires specialist software and the accuracy and resolution are variable. It is possible to purchase high-resolution DEM generated from high-resolution satellite imagery, but the cost is extremely high.

There are two satellite-derived DEM that are freely available and cover the area of Stelae Ridge. These are the ASTER GDEM2 and the SRTM global digital elevation model.[205]

4.2.1. ASTER GDEM2

The ASTER GDEM2 tile N22_E031 covering the Gebel el-Asr region and Stelae Ridge was obtained from the USGS (Fig 4.1).[206] It clearly shows the main landscape features of the Gebel el-Asr region. The Gebel Uweinat road appears as a dark line running roughly north to south to the east of Stelae Ridge. The largest canal, the Sadat canal, which now forms the main canal of the Tushka Project, appears very clearly as a large low dark strip to the east of the Gebel Uweinat road. Other roads appear as thin white lines and other canals of the Tushka Project appear as darker lines.

---

[203] Typically either a Total Station or differential GPS.
[204] For examples of DEM created from aerial photography and satellite imagery see Bewley and Raczkowski (2002); Casana and Cothren (2008); Conolly and Lake (2006, 72–76); and Hritz and Wilkinson (2006).
[205] For the origin and specifications of these DEM see Chapter 2, section 2.2.4 and 2.2.5.
[206] http://dds.cr.usgs.gov/srtm/ or http://earthexplorer.usgs.gov/, last accessed 20 October 2014.

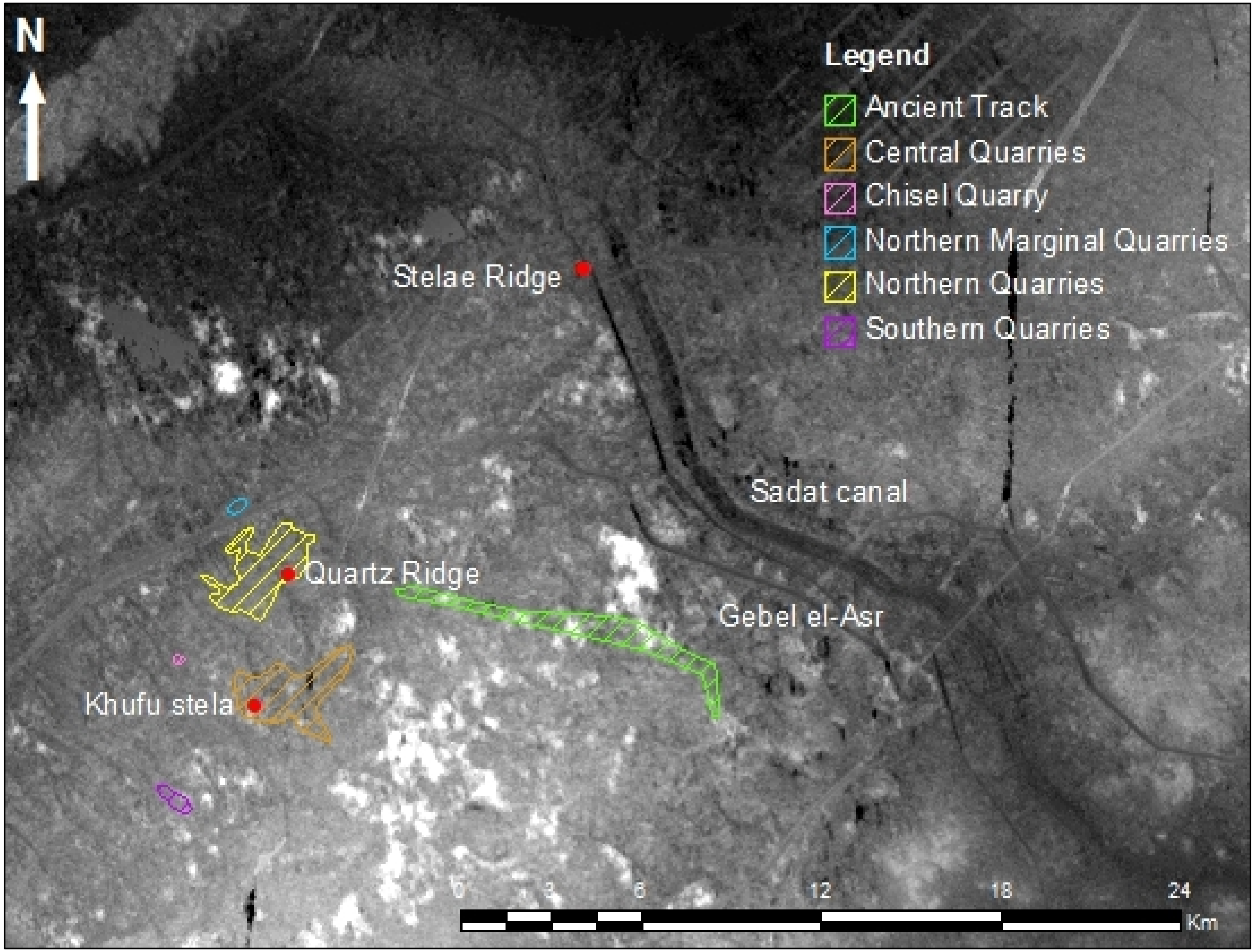


Fig 4.1: ASTER GDEM2 image of the Gebel el-Asr region. Darker areas represent lower land and lighter areas represent higher land. Archaeological sites and locations, taken from the Gebel el-Asr Project data, are shown overlying ASTER GDEM2 tile N22_E013, available from the USGS.

Unfortunately Fig 4.1 also reveals a number of defects in the ASTER GDEM2 tile. These appear as bright white patches, which have much higher height readings than is possible in this area of desert. The most notable is an area around and to the west of the Gebel el-Asr, which has almost completely obscured the gebel, located west of the ‘Gebel el-Asr’ label in Fig 4.1. The ASTER GDEM2 pixel values, which reflect the height of the land, are typically over 300m in this area. As the Gebel el-Asr is only 260m high and the land to the west is much lower, these values must reflect a defect in the ASTER GDEM2.

There is another area to the south of Stelae Ridge where pixel values are *c.* 290m, even though the land is actually lower than or equal to the *c.*190m at Stelae Ridge. Other amorphous white areas are visible across the rest of the ASTER GDEM2 image, running diagonally across the image from south-west to north-east. These features suggest that an area of small clouds was moving across the site when the satellite image was recorded. The reflections from these clouds were processed with the reflections from the ground, resulting in inappropriately high readings where clouds were located and rendering the terrain model entirely unlike the actual ground surface. Any visibility analysis based upon it is likely to be highly inaccurate.

4.2.2. SRTM

The SRTM tile (Fig 4.2) covering Stelae Ridge and the Gebel el-Asr region gives the same general impression of the Gebel el-Asr landscape as the ASTER GDEM2, but the lower resolution resulted in the absence of several smaller features. The Sadat canal is still visible, but several minor canals and the Gebel Uweinat road are not. However, the SRTM does not suffer from the cloud-cover that produced defects in the ASTER GDEM2.

4.2.3. The DEM for the visibility analysis of Stelae Ridge

The ASTER GDEM2 is the best resolution freely available DEM that covers the Stelae Ridge area, but the tile of the Stelae Ridge area has a number of defects associated with cloud cover during remote sensing.

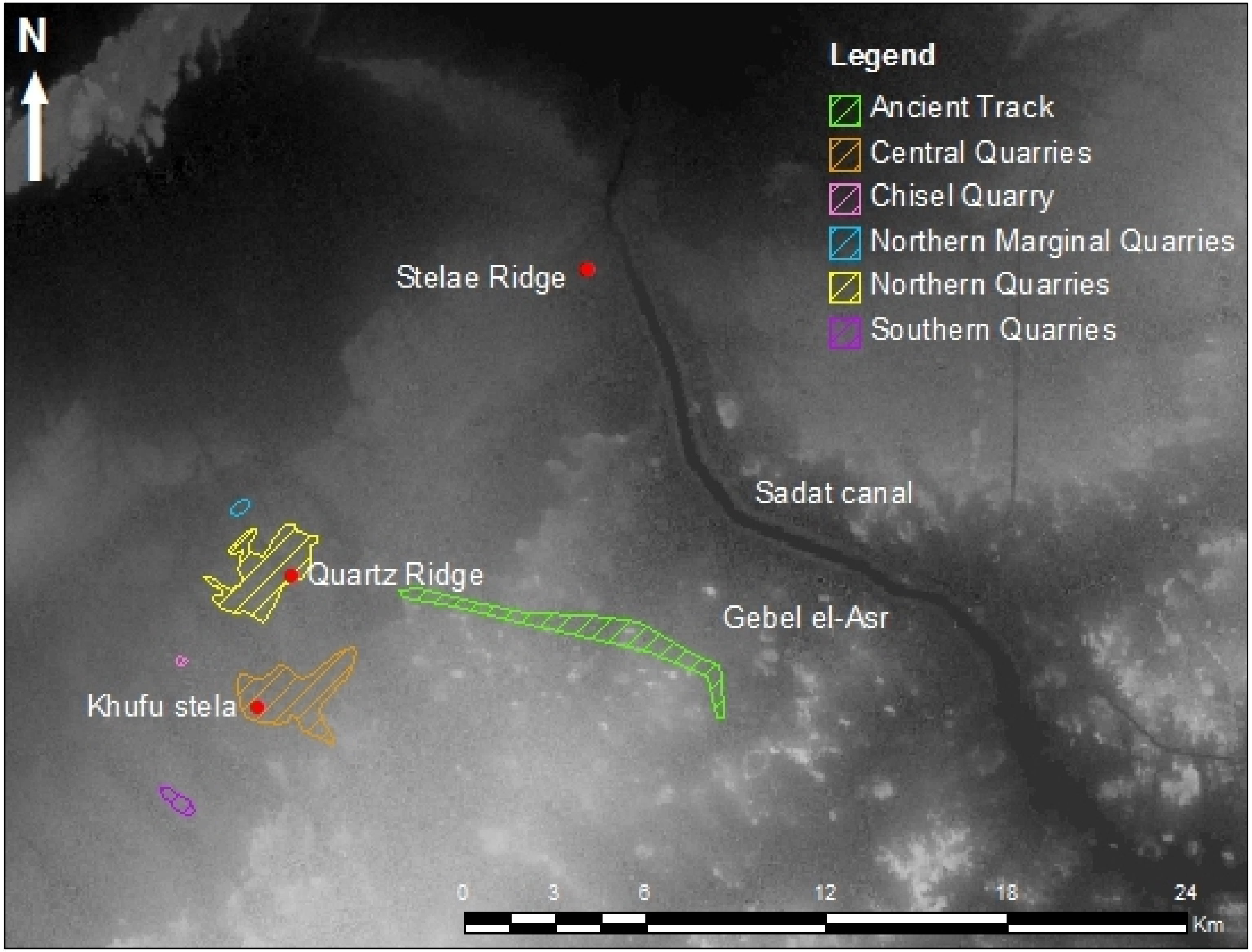


Fig 4.2: SRTM of the Gebel el-Asr region. As before darker areas are lower and lighter areas are higher. The archaeological sites and locations, taken from the Gebel el-Asr Project data, are shown overlying SRTM tile n22_e031_3arc_v2, available from the USGS.

To assess the effect of the ASTER GDEM2 defects upon visibility analysis, viewshed analysis was undertaken using the ASTER GDEM2 and the SRTM. The viewshed analysis was undertaken in ArcGIS 10 using the 'Viewshed'[207] tool of the 'Visibility' toolset in the '3D Analyst' toolbox. The observer location, observer offset, target offset and ground level were set to the same parameters for both viewshed analyses. The resulting viewsheds showed what ground was visible to a 1.65m observer standing at the north end of Stelae Ridge according to the ASTER GDEM2 (Fig 4.3) and according to the SRTM (Fig 4.4).

The effects of the inaccuracies in the ASTER GDEM2 are clearly evident in Fig 4.3. The viewshed analysis suggests visibility would be limited to the south of Stelae Ridge and both the Gebel el-Asr and 20 cairn hill would not be visible. Experience has shown that visibility is actually very good to the south of Stelae Ridge.[208] Gebel el-Asr and 20 cairn hill are both normally visible and, on good days, some of the gebels further south can be discerned. The viewshed analysis derived from the SRTM (Fig 4.4) is much more accurate than that produced by the ASTER GDEM2, even though the SRTM has a lower resolution. It correctly shows good visibility to the south of Stelae Ridge, including the Gebel el-Asr, 20 cairn hill and some of the gebels further south. Despite its lower resolution, the absence of defects mean the SRTM model produces more accurate and reliable results than the ASTER GDEM2, and will therefore be used in the visibility analysis.

[207] Details of the viewshed analysis processing tool of ArcGIS are provided at http://resources.arcgis.com/en/help/main/10.1/index.html#/Performing_visibility_analysis_with_Viewshed_and_Observer_Points, last accessed 18 March 2013.
[208] The author's experience of visibility at the site is discussed in Chapter 3, section 3.7.2.

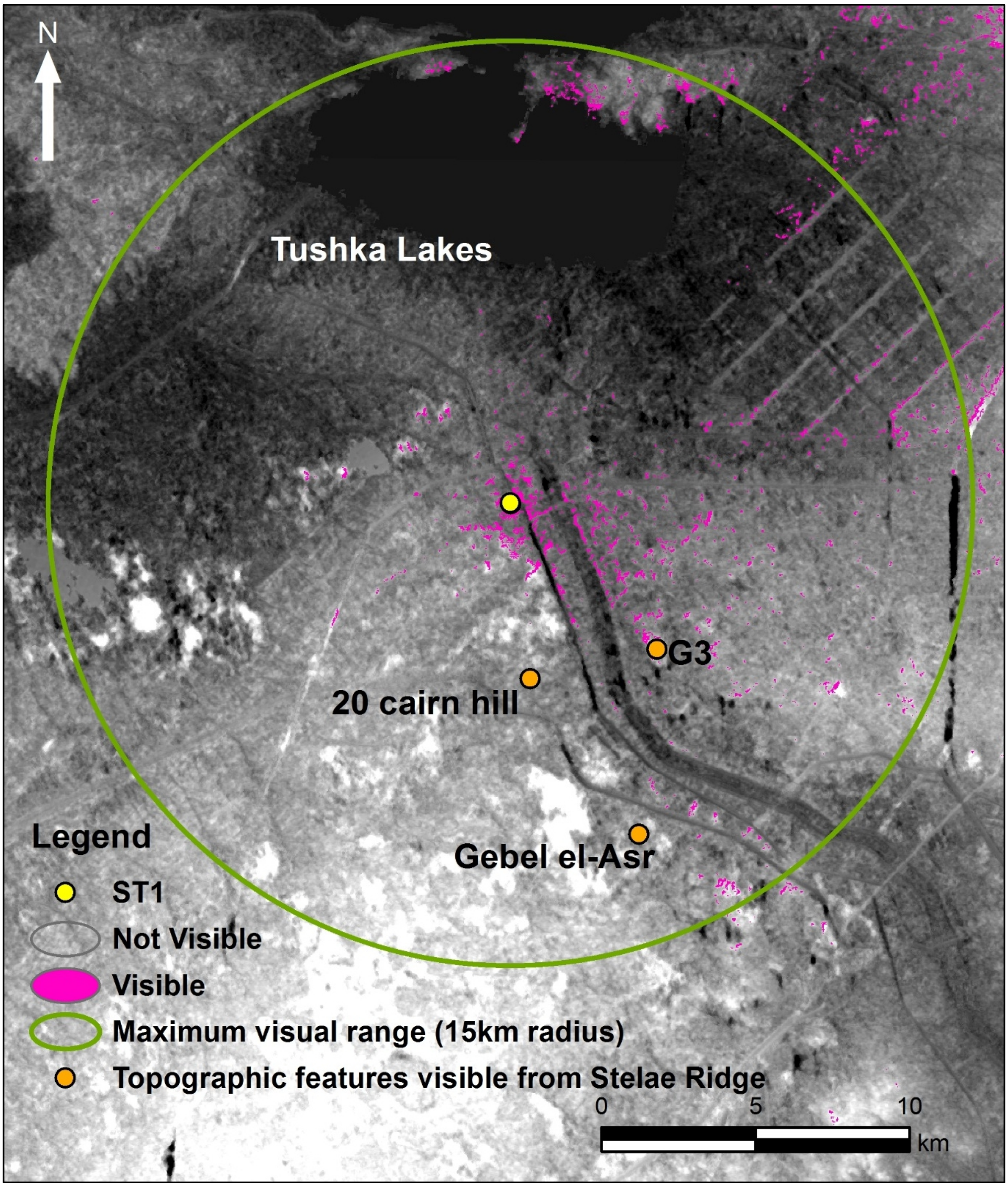


Fig 4.3: Viewshed analysis using ASTER GDEM2 data, showing in purple the areas visible to a 1.65m observer at the north end of Stelae Ridge. The maximum visual range is a radius of 15km from Stelae Ridge. Note how the viewshed analysis suggests poor visibility for the areas south of Stelae Ridge, including the Gebel el-Asr and 20 cairn hill, even though practical experience has shown that these areas are visible. G3 is an unnamed hill observed by the author from Stelae Ridge. The viewshed is shown overlying the ASTER GDEM2 (ASTER data distributed by the Land Processes Distributed Archive Centre (LP DAAC), located at USGS/EROS, http://lpdaac.usgs.gov).

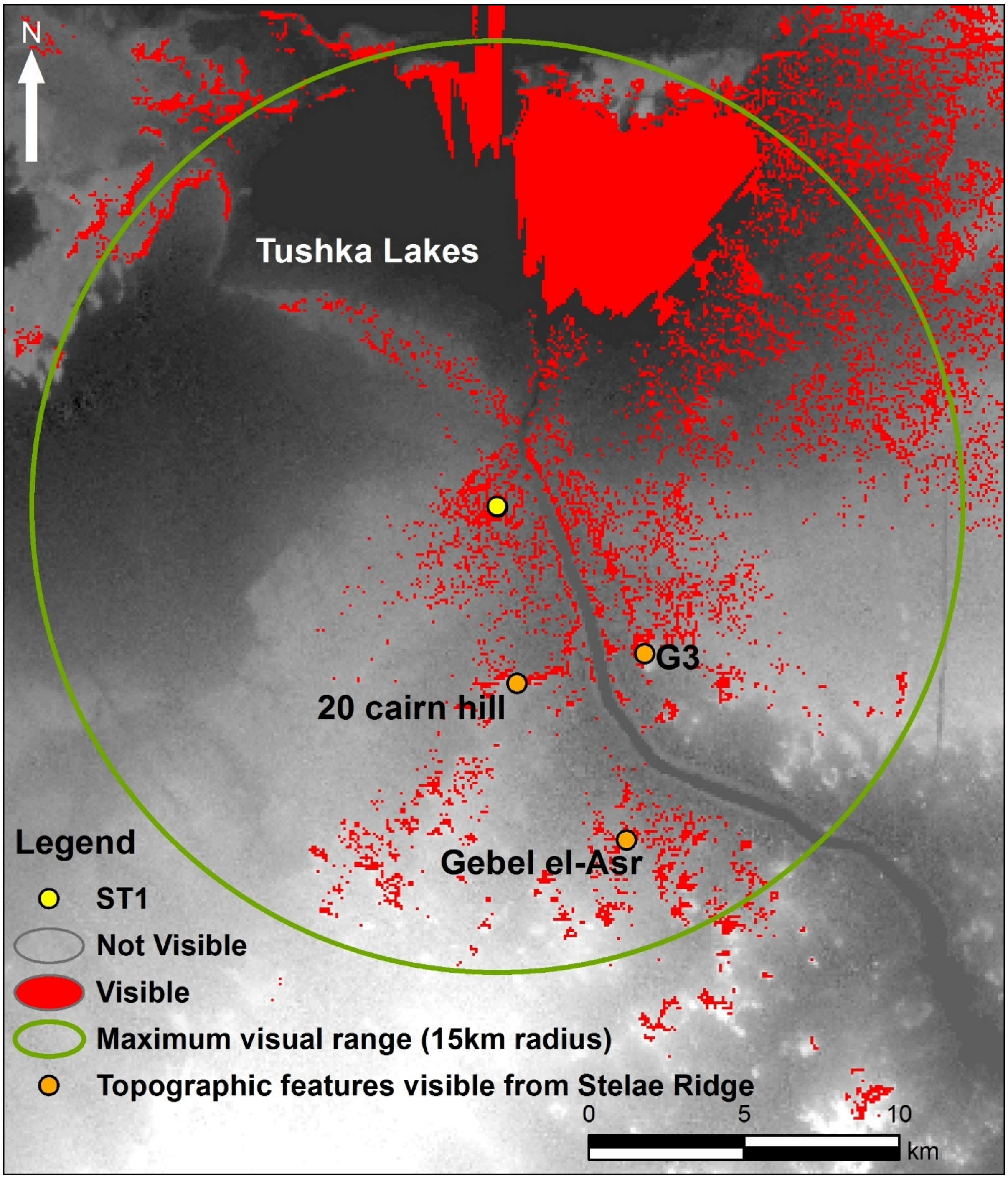


Fig 4.4: Viewshed analysis using SRTM data, showing in red the areas visible to a 1.65m observer at the north end of Stelae Ridge. The maximum visual range is a radius of 15km from Stelae Ridge. G3 is another unnamed hill observed by the author from Stelae Ridge. The SRTM has produced a much more accurate representation of the visibility at Stelae Ridge, even though it is lower resolution than the ASTER GDEM2. The viewshed is shown overlying the SRTM (SRTM data available from the USGS).

4.2.4. Hybrid DTM

Although the SRTM provides a reasonably accurate freely available DEM for the Stelae Ridge area, it would be preferable to have a higher resolution model around Stelae Ridge itself. High-resolution DEM purchased from external providers are too expensive and the specialist software required to create custom DTM from satellite images is not available to this project, so a method was developed for creating a hybrid DTM out of a mixture of freely available satellite DEM and limited topographic survey. This method was developed and tested at Medinet el-Gurob in the Faiyum.[209]

The research revealed that the hybrid DTM produced more accurate and reliable visibility analysis than unmodified, satellite-derived DEM. Unfortunately, the 2012 survey at Stelae Ridge was severely curtailed by administrative problems. The topographic survey could not be undertaken and the proposed hybrid DTM had to be abandoned.[210] As a result the unmodified SRTM tile for Stelae Ridge provided the DEM for all the visibility analysis undertaken during this research.

4.3. Sensitivity of the SRTM

The DEM is only a model of the landscape, and the degree to which it is an accurate model will affect the results of any visibility analysis undertaken using it. Testing the sensitivity of the DEM to changes in observer height is a good test of the general accuracy of the landscape model and whether the results derived from it are likely to be robust or not (Conolly and Lake 2006, 230; Lock and Harris 1996).

Several sensitivity tests of the SRTM were undertaken. Following similar sensitivity tests of the Gurob hybrid DTM and the unmodified ASTER GDEM2 tiles of the Gurob area, it was considered unlikely that viewshed analyses based on the SRTM would be very sensitive to changes in observer height within the range of adult Middle Kingdom stature. To determine whether this hypothesis was correct, a series of viewshed analyses were run using the SRTM and observer offsets representing a range of Middle Kingdom adult heights 1.50–1.75m.[211]

The test was run twice. The observer location, ground level at observer location and target offset were kept the same. The observer offset, representing the height of the observer above the ground, was changed in intervals of 0.05m from 1.5m to 1.75m. The first test took

---

[209] For the topographic survey and terrain model of Medinet el-Gurob see Jones and Pethen (2012).
[210] This is discussed in Chapter 3 section 3.7.1.
[211] Evidence for the height of Middle Kingdom adults is presented in Chapter 2, section 2.6.1.

no account of the curvature of the earth and the refraction of light (Fig 4.5). The second test (Fig 4.6) made use of the earth curvature and refractivity coefficient in ArcGIS 10.1 to correct for these factors.[212]

Comparison of Fig 4.5 and Fig 4.6 reveals that whether or not the viewshed analysis corrected for the curvature of the earth and refraction, the viewsheds remain very consistent for the different observer heights. Fig 4.7 and Fig 4.8 are details of Fig 4.5 and Fig 4.6 respectively. They confirm that even close to Stelae Ridge, the viewsheds are generally consistent for different observer heights.

To quantify these results, the areas of the viewsheds were calculated. Table 4.1 shows the area visible to observers of 1.5–1.75m, together with the increase represented by each 0.05m increase in observer height. The increase is shown in km^2 and as a percentage increase from the area of the preceding viewshed in the table.

Table 4.1: Change in the area of the viewshed, resulting from changes in observer height.

	With adjustment for curvature of the earth and refraction of light			Without adjustment		
Observer height (m)	**Viewshed area (km^2)**	**Increase (km^2)**	**Increase (%)**	**Viewshed area (km^2)**	**Increase (km^2)**	**Increase (%)**
1.50	140.94	-	N/A	339.20	-	N/A
1.55	141.61	0.67	0.48	339.99	0.79	0.23
1.60	142.20	0.59	0.42	340.90	0.91	0.27
1.65	142.78	0.58	0.41	341.86	0.96	0.28
1.70	143.41	0.63	0.44	342.76	0.90	0.26
1.75	144.21	0.80	0.56	343.70	0.94	0.27

Table 4.1 shows that the increase in the area of the viewsheds, both as an area and as a percentage, is very consistent across all the relevant observer heights. Both the appearance and sizes of the viewshed suggest that changes within this range of observer heights do not produce much variation in the size of the viewshed.

[212] For details of how this is accomplished in ArcGIS 10.1 see http://resources.arcgis.com/en/help/main/10.1/index.html#/Performing_visibility_analysis_with_Viewshed_and_Observer_Points/009z000000v8000000/, last accessed 11 October 2014.

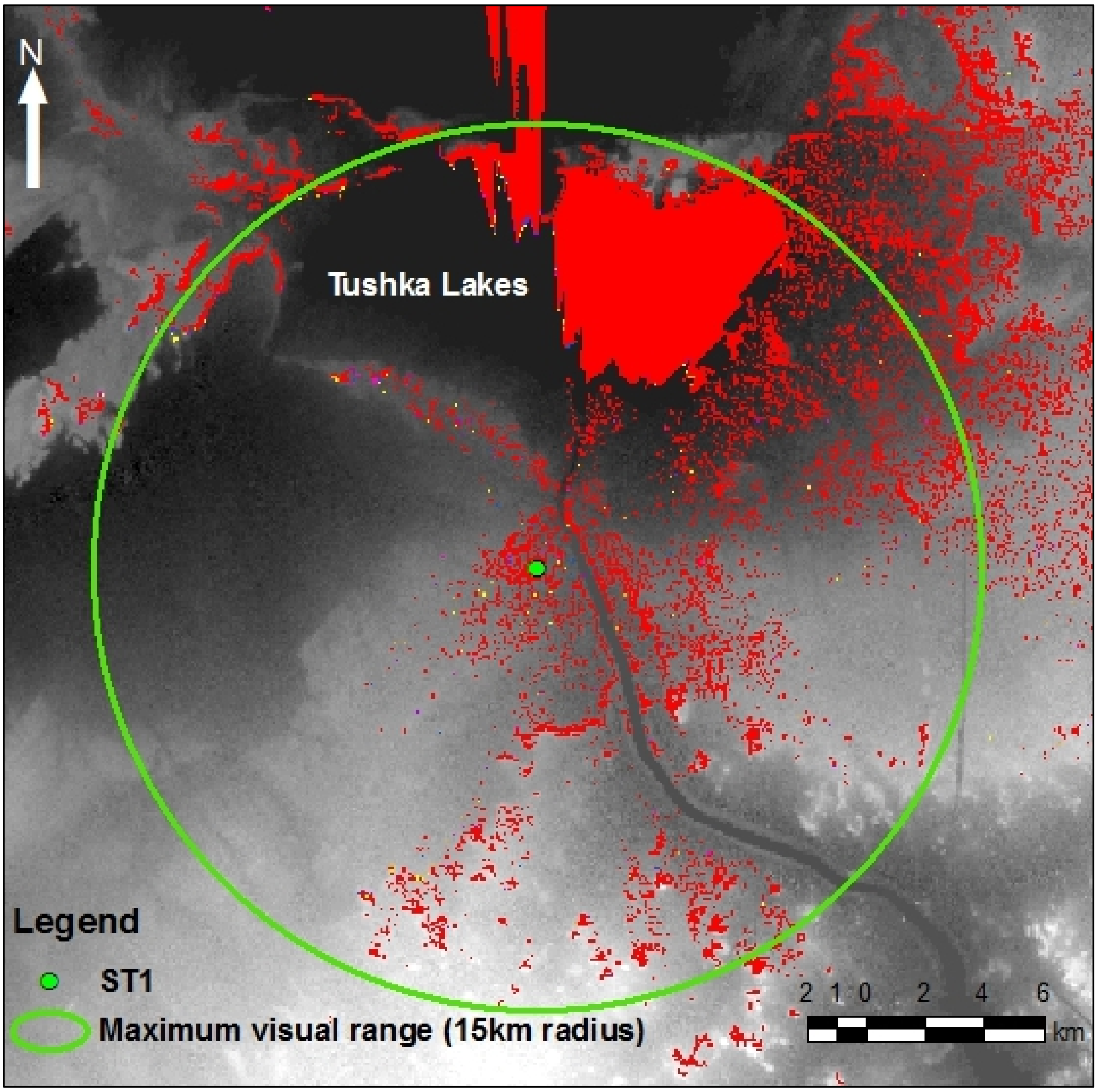


Fig 4.5: Viewshed change with observer height, showing how much additional area is added to the viewshed by increasing the observer height. The viewsheds are superimposed, with the smallest viewshed (observer of 1.50m) on top and the largest viewshed (observer of 1.75m) on the bottom. The colours are therefore cumulative; the observer of 1.50m could only see the red areas, one of 1.55m could see both red and blue; 1.60m could see red, blue and orange. The dominance of the red viewshed and the almost invisible area occupied by other colours indicates the consistency of the viewshed analysis and the low sensitivity of the SRTM. There is no correction for the curvature of the earth or refraction of light. (SRTM data from the USGS).

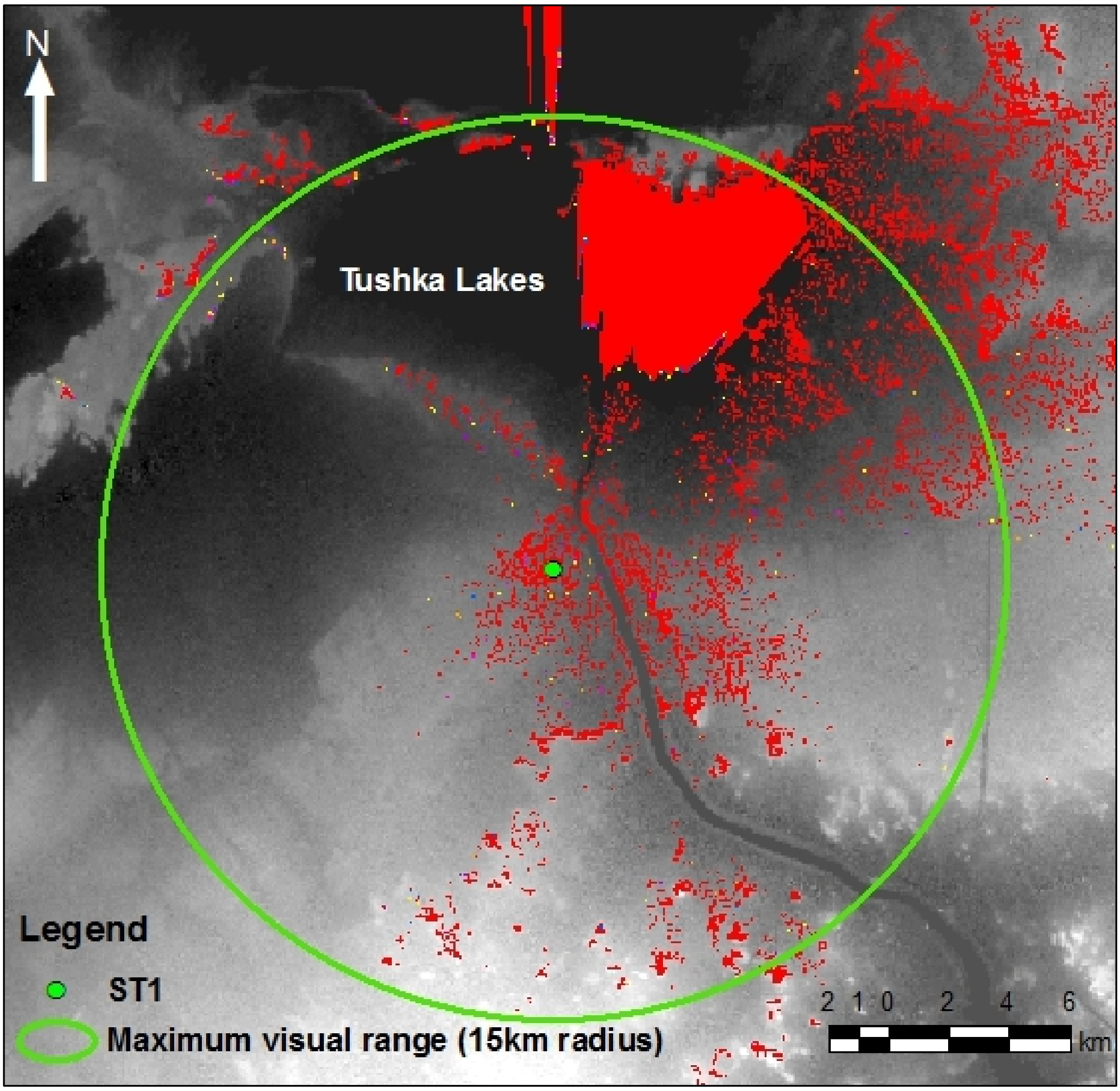
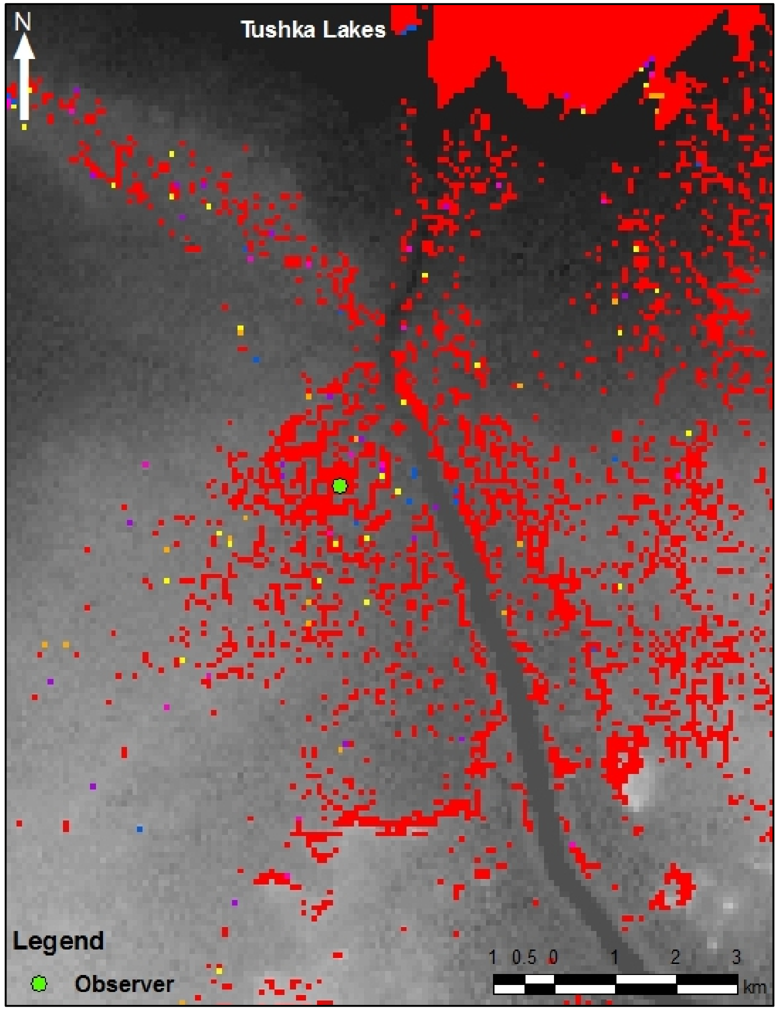


Fig 4.6: Viewshed change with observer height, with correction for the curvature of the earth and the refraction of light. The colours are the same as the previous figure and the viewsheds superimposed in the same way. The dominance of the red viewshed and the almost invisible area occupied by other colours indicates the consistency of the viewshed analysis and the low sensitivity of the SRTM to changes in observer height 1.5–1.75m. (SRTM data available from the USGS).



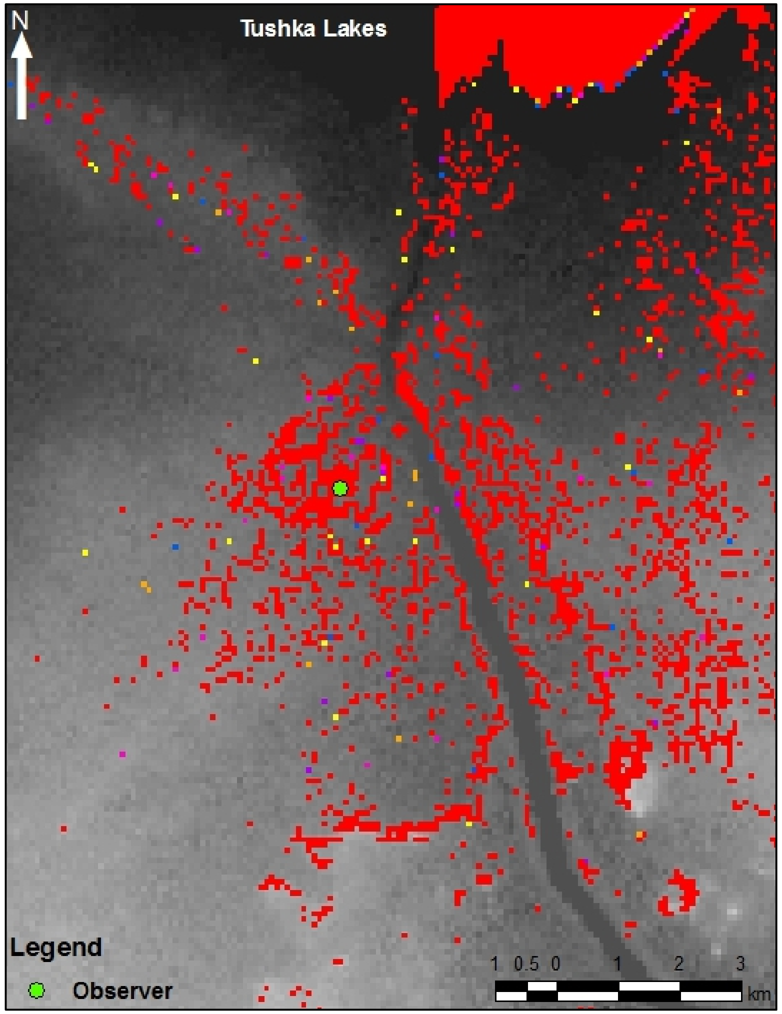


Fig 4.7 (left) and Fig 4.8 (right): Details of Fig 4.5 and Fig 4.6 respectively, showing that even close to Stelae Ridge, changes in observer height have limited effect upon the resulting viewsheds. SRTM data shown underlying the viewsheds. (SRTM data available from the USGS).

To assess the overall sensitivity of the SRTM, viewsheds were calculated at 0.1m intervals for observer heights 0.0–3.0m. Other than the changes in observer height, the other variables were kept consistent. Table 4.2 shows the results of this research. Chart 4.1 and Chart 4.2 respectively show the results from Table 4.2 for viewsheds with adjustment for the curvature of the earth and those without.

Table 4.2: Changes in viewshed area with 0.1m changes in observer height between 0.0–3.0m for viewsheds based on SRTM.

Observer height	With adjustment for curvature of the earth and refraction of light			Without adjustment		
	Viewshed area (km^2)	Increase (km^2)	Increase (%)	Viewshed area (km^2)	Increase (km^2)	Increase (%)
0.00	109.78	-	N/A	287.00	-	N/A
0.10	112.12	2.34	2.13	294.22	7.22	2.52
0.20	115.04	2.92	2.60	301.40	7.18	2.44
0.30	118.00	2.96	2.57	307.02	5.62	1.86
0.40	120.86	2.86	2.42	311.72	4.70	1.53
0.50	123.56	2.70	2.23	316.29	4.57	1.47
0.60	126.21	2.65	2.14	320.37	4.08	1.29
0.70	128.53	2.32	1.84	323.50	3.13	0.98
0.80	130.17	1.64	1.28	325.88	2.38	0.74
0.90	132.21	2.04	1.57	328.05	2.17	0.67
1.00	134.04	1.83	1.38	330.37	2.32	0.71
1.10	135.60	1.56	1.16	332.14	1.77	0.54
1.20	137.13	1.53	1.13	334.33	2.19	0.66
1.30	138.48	1.35	0.98	336.03	1.70	0.51
1.40	139.74	1.26	0.91	337.74	1.71	0.51
1.50	140.94	1.20	0.86	339.20	1.46	0.43
1.60	142.20	1.26	0.89	340.90	1.70	0.50
1.70	143.41	1.21	0.85	342.76	1.86	0.55
1.80	144.87	1.46	1.02	344.59	1.83	0.53
1.90	146.45	1.58	1.09	346.47	1.88	0.55
2.00	147.71	1.26	0.86	348.78	2.31	0.67
2.10	149.19	1.48	1.00	350.64	1.86	0.53
2.20	150.47	1.28	0.86	352.39	1.75	0.50
2.30	151.83	1.36	0.90	354.31	1.92	0.54
2.40	153.07	1.24	0.82	356.16	1.85	0.52
2.50	154.24	1.17	0.76	358.06	1.90	0.53
2.60	155.40	1.16	0.75	359.87	1.81	0.51
2.70	156.68	1.28	0.82	361.62	1.75	0.49
2.80	157.79	1.11	0.71	363.42	1.80	0.50
2.90	158.92	1.13	0.72	365.20	1.78	0.49
3.00	160.05	1.13	0.71	367.30	2.10	0.58

Chart 4.1: Changes in viewshed area with observer height 0.0–3.0m for viewsheds based on SRTM, allowing for the curvature of the earth and refraction of light.

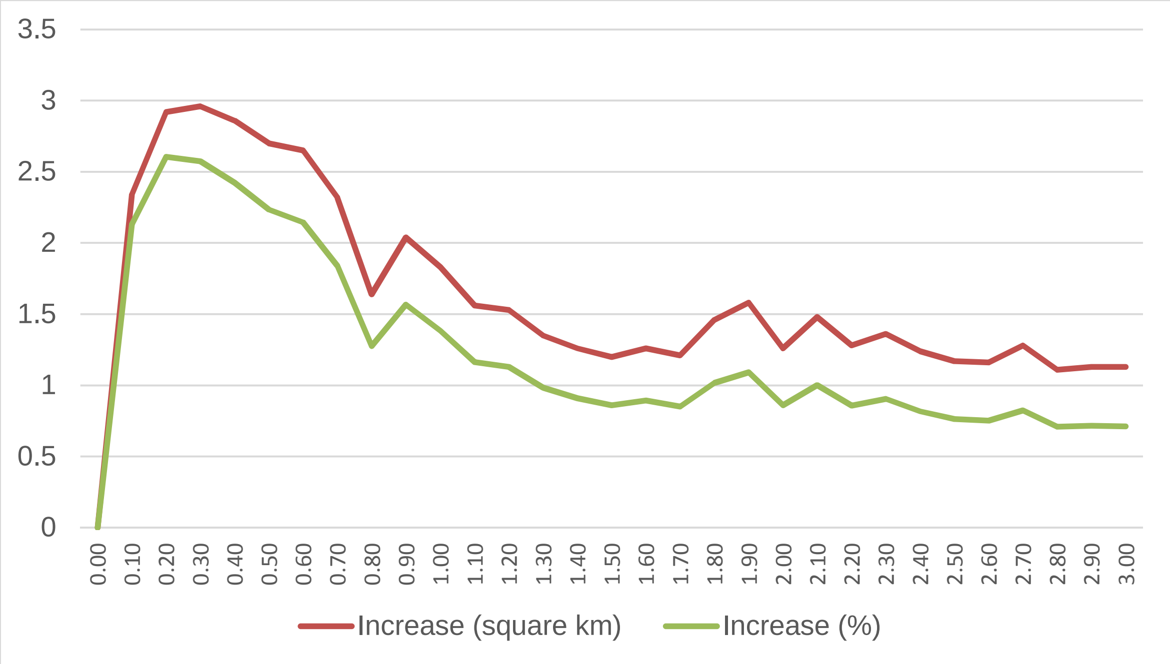


Chart 4.2: Changes in viewshed area with observer height 0.0–3.0m for viewsheds based on SRTM, without adjustment for the curvature of the earth and refraction of light.

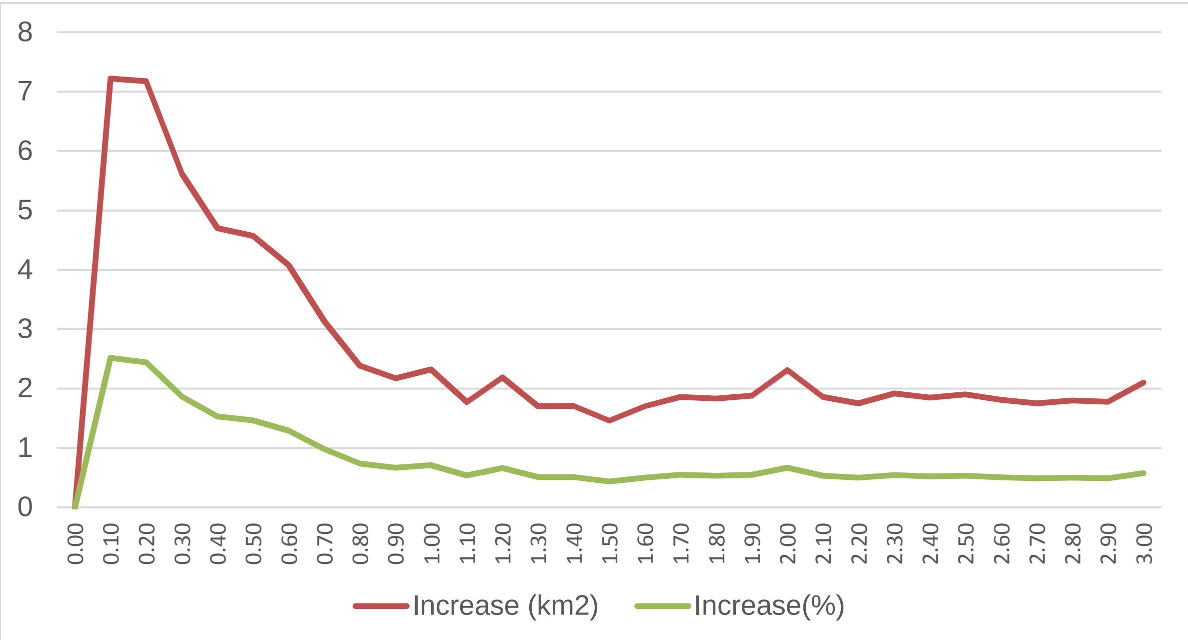


Chart 4.1 and Chart 4.2 reveal that observer heights of less than 1m produce very high variation in the area of the resulting viewshed. Viewsheds derived from the SRTM are therefore very sensitive to low observer heights. But while notable variation continues up to 1.3m in both charts, where there is adjustment for the curvature of the earth and refraction of light variation continues up to 2.2m (Chart 4.1). These 'sensitivity thresholds' reveal the heights above which changing observer height makes much less difference to the resulting viewshed size, and provide a means of comparing the sensitivity of DEMs. The variation up to 2.2m for the viewsheds calculated with adjustment for the curvature of the earth and refraction of light, probably reflects the more complex algorithms used to calculate viewsheds that take account of these factors. Calculating viewsheds without these variables is a simpler process and produces a more straightforward increase in viewshed area with observer height.

Despite the noticeable variation up to 2.2m in viewsheds generated using the SRTM with correction for the curvature of the earth and refraction coefficient, all the tables and charts indicate that within the range of 1.5–1.75m of adult Middle Kingdom stature there is minimal variation and the results are likely to be robust irrespective of whether a viewshed analysis is calculated using a height of 1.5m or a height of 1.75m.

During the test of the Gurob hybrid DTM, the sensitivity thresholds of the ASTER GDEM2 and the hybrid DTM were calculated for the Gurob area. These sensitivity thresholds may not be directly comparable to the SRTM, since they reflect the terrain at Gurob rather than the terrain at Gebel el-Asr and a different DEM. Nevertheless it is noticeable that the hybrid DTM sensitivity threshold of 0.6m is substantially lower than the SRTM. The ASTER GDEM2 threshold of 1.7m is higher than the SRTM threshold of 1.3m.[213] The SRTM was expected to have a higher sensitivity than the hybrid DTM, since the hybrid DTM had been enhanced with topographic survey data in the area around Gurob and was therefore more accurate. However, these results also suggest that the SRTM model of Gebel el-Asr is more accurate than the ASTER GDEM2 model of Gurob, even though the latter had a higher resolution and was not apparently subject to cloud-related artefacts.

Since it was not possible to undertake the topographic survey of Gebel el-Asr and create a hybrid DTM, the SRTM represents the most accurate model of the landscape available for this project. Furthermore, the sensitivity tests suggest that the visibility analysis produced by

---

[213] Because the sensitivity thresholds for the Gurob ASTER GDEM2 and hybrid DTM were calculated from viewsheds that did not take account of the curvature of the earth and the refraction of light, it is not appropriate to compare them with the SRTM sensitivity threshold of 2.20m for viewsheds calculated with correction for these factors.

the SRTM will be reasonably robust for individuals within the normal range of adult Middle Kingdom height 1.5–1.75m.

4.4. The Middle Kingdom landscape

Its reasonable resolution, the sensitivity tests and the absence of the defects present in the ASTER GDEM2 suggest the SRTM is a reasonably good model of the modern landscape, but they do not reveal whether the SRTM represents a good model of the Middle Kingdom landscape.

It has long been recognised that the reliability of GIS-based visibility analyses depends on the inclusion of short and long-term environmental change (Conolly and Lake 2006, 228; Wheatley and Gillings 2000). Various attempts have been made to incorporate the impact of environmental variables into visibility analysis in order to improve the modelling of visibility within current and past landscapes.[214] All these methods depend directly upon archaeological, geomorphological, palaeoecological and climatic data to provide evidence for the climate, geomorphology and ecology of the landscape in the past (Fraser 1983; Maschner 1996; Wheatley 1996).

The following sections consider the available evidence concerning the hydrology, climate and ecology and geology and topography of Stelae Ridge in the Middle Kingdom and how far these differ from modern conditions.

4.4.1. Climate and rainfall

Climatic, environmental, archaeological and geomorphological investigations of the eastern Sahara have shown that between *c.* 9300–6300 BP (9000–5300 cal. BC) the eastern Sahara experienced increased rainfall and a savannah environment during the 'Holocene Wet Phase'.[215] Seasonal lakes developed in lower areas of the Sahara, including a series of lakes in the Kharga depression (Bunbury and Ikram 2014).

From *c.* 6300 BP the monsoon rains of the Inter-tropical Convergence Zone (ITCZ) moved further south and the eastern Sahara, including Nile valley, experienced steadily declining

---

[214] Methods have been suggested for modelling the impact of vegetation (Chapman and Geary 2000; Llobera 2007a; Wheatley and Gillings 2000), changing light refraction, illumination and contrast (Fisher 1994; Ogburn 2006; Wheatley and Gillings 2000), and long-term changes in topography, ecology and climate (Fisher 1991; Fraser 1983; Lock and Harris 1996).
[215] For the Holocene Wet Phase see Haynes (1987; 2001); Hoelzmann (2002); Kröpelin (1987); Schild and Wendorf (2001b); Wendorf (1977); Wendorf *et al.* (2001).

rainfall.[216] As the drying was driven by the southwards migration of the monsoon rains, northerly latitudes, including northern Egypt, would have been affected first, followed by areas progressively further south.[217] Much of Egypt reached present climatic conditions towards the end of the Old Kingdom and First Intermediate Period *c.* 2200BC (Bell 1971; Hassan 1996), but Stelae Ridge would have retained its hospitable environment longer than more northerly locales in the rest of Egypt.

Within the overall trend of an increasingly dry Sahara, recent investigations have revealed regular fluctuations in the quantity of rainfall and therefore in the resulting environment.[218] There is evidence of a late predynastic and Old Kingdom humid period in the south-western desert of Egypt followed by a hyper-arid phase, and a later wet phase around the early Middle Kingdom (Schild and Wendorf 2013, 129).

Evidence from the Gebel el-Asr quarries, to the south of Stelae Ridge, also suggests that the site experienced wetter and more hospitable conditions during the Old Kingdom and the early Middle Kingdom, with an arid period between. The Gebel el-Asr Project excavated a number of wells at Old Kingdom settlements and along the track to the Nile.[219] The three wells were found to be less than 1m deep. The water in them may have originated in the Nubian sandstone aquifer (Bloxam 2003b, 69) which was recharged during the Holocene Wet Phase and still supplies the low-lying oases of the western desert (Ball 1927).

In addition to the wells, the stratigraphy revealed that the Old Kingdom structures had been built on or cut into a ground surface comprising a playa mud or siltstone, exposed and desiccated to produce a stable crust or duricrust.[220] The duricrust contained remains of a species of aestivating snail, which is still found in certain areas of the Middle East and can survive without water for up to seven years.[221] The presence of this species suggests that the Old Kingdom climate was sufficiently wet that the snails could expect rain within seven years, but also sufficiently dry that only an aestivating species could survive.

Evidence of a more hospitable desert environment in the Old Kingdom is also present in epigraphic evidence (Bloxam 2003b, 73–74). The stela of Khufu from the gneiss quarries includes the name of the district where they were located. Rowe (1939, 394–5) translates

---

[216] For the changing climate in the eastern Sahara see Bubenzer and Riemer (2007); Eggermont *et al.* (2008); Hoelzmann *et al.* (2000); Kröpelin *et al.* (2008); Kuper and Kröpelin (2006).
[217] For Chad see Kröpelin *et al.* (2008), for Sudan see Neumann (1989) and for Gilf Kebir see Hassan (1996); Kuper and Kröpelin (2006).
[218] This is also consistent with Greenland ice cores (Thomas *et al.* 2007).
[219] Shaw *et al.* (2004a; 2010, 304);
[220] Bunbury (1999); Shaw *et al.* (2010).
[221] J. Bunbury pers comm.

the name of the district as ‘Place of the Fisher’ or ‘Place of Catching Birds’, and interpreted it as a fertile ‘oasis’ (Bloxam 2003b, 74). The attestation of this name during the reign of Khufu is consistent with other evidence of a wetter environment in the early Old Kingdom.

Above the duricrust were varying depths of aeolian deposits,[222] which provide evidence of a hyper-arid phase after the Old Kingdom at Gebel el-Asr. Several Old Kingdom settlements in the vicinity of the ancient capital of Memphis were overtaken by aeolian sand and abandoned, aeolian sand deposits from the same period were also found further south in Middle Egypt.[223] Although the great distance between these locations and Gebel el-Asr makes it unlikely that the deposition of aeolian sand occurred during the same event, it is tempting to see them all as symptoms of the changes to the Egyptian climate, which took place at the end of the Old Kingdom and resulted in the deposition of aeolian sands over previously occupied areas along the Nile valley.

The renewed interest in Gebel el-Asr and Stelae Ridge in the Middle Kingdom might well reflect the impact of a slightly wetter environmental phase, as much as the renewed vigour of the reunified state, but it is unlikely to have been very wet. Even during the Old Kingdom the snails found in the duricrust were a species resistant to drought. The ephemeral structures at the gneiss quarries also suggest that quarrying was a temporary activity in both the Old and Middle Kingdoms (Shaw *et al.* 2010, 300). Temporary, probably seasonal, quarrying expeditions would not require as hospitable an environment as nomadic pastoralism or regular transhumance. Resources, including meat on the hoof could be brought with the quarry workers and additional provisions could be supplied from the Nile valley.[224]

The overall trend was for an increasingly dry Sahara. Stelae Ridge is too far north to have had a lot of rainfall,[225] particularly in the Middle Kingdom. At Nabta Playa, south-west of Stelae Ridge, the Holocene climate ranged from austere desert to semi-desert, being sahel at best, even during humid periods (Wendorf *et al.* 2001, 49). Slightly further north, at Gebel el-Asr and Stelae Ridge, it is likely that the rains would have been intermittent and might have failed for several years. Although some occasional rainfall might be expected due to

---

[222] Shaw *et al.* (2004a, 4; 2010, 296).
[223] For aeolian deposits at Memphis see Giddy and Jeffreys (1992) and Jones (1995). For aeolian deposits further south in Middle Egypt see Butzer (1961; 1982) and Mortensen (1991).
[224] There is evidence for the storage of provisions at Gebel el-Asr in the form of the 22 Middle Kingdom storage jars from Quartz Ridge (Shaw *et al.* 2001). Burnt animal bone at the settlement at Khufu Stela suggests meat was consumed and sheep/goat bone from SP90 close to Quartz Ridge might indicate what type of animal (Shaw *et al.* 2004a). Animal coprolites at Quartz Ridge (Shaw *et al.* 2010, 300) could indicate the presence of animals for transport or food.
[225] Kuper and Kröpelin (2006, 804); Kröpelin *et al.* (2008).

the humid phase, the site was probably closer to semi-desert than sahel in the Middle Kingdom.

4.4.2. Hydrology and vegetation

The nearest natural source of water is currently Lake Nasser *c.* 37.3km east of the site at Wadi Tushka. The Survey of Egypt 1: 500,000 scale map of 1944 shows that prior to the construction of the Aswan High Dam the Nile was actually located *c.* 69.8km south-east of the site at Ineiba (Fig 4.9).[226] Since the Nile had developed its present form and regimen by *c*. 8000 BC (Said 1993, 23–24), the Nile would have been located in approximately[227] the same position in the Middle Kingdom. The only source of water locally would therefore have been the rains and well water from the Nubian sandstone aquifer.

The climatic information discussed in the preceding section suggests that the wet phase of the Middle Kingdom was rather drier than the preceding Old Kingdom wet phase, with an environment closer to semi-desert than sahel. While there may have been slightly more vegetation than the current hyper-arid conditions, it is doubtful that there would have been sufficient to obscure visibility.

4.4.3. Geology and topography

The topography of Gebel el-Asr and Stelae Ridge reflects the underlying Precambrian metamorphic basement and the subsequent Pleistocene and Holocene deposits. The outcrops of gneiss and igneous dykes across the site are elements of the pre-Pleistocene geology (Klemm and Klemm 2008, 325–6). The overlying playa silts that form the Old Kingdom duricrust reflect the presence of playas, perhaps even the Pleistocene Kharga to Tushka palaeolakes (Haynes 1980; Bunbury and Ikram 2014; Maxwell *et al.* 2010). The underlying topography was therefore present long before the Middle Kingdom activity at Stelae Ridge.

---

[226] The author is grateful to CAMEL of the Oriental Institute Chicago, for providing this map.
[227] Evidence from various Egyptian sites indicates that the Nile has moved within the valley floodplain throughout Egyptian history (Bunbury and Jeffreys 2011; Bunbury *et al.* 2009; Graham 2010; Graham *et al.* 2012; Hillier *et al*.2007; Jeffreys 1996; Jeffreys and Tavares 1994; Jones 1995; 1997). However, at any given location, this movement has necessarily been limited by the maximum width of the Nile valley. Furthermore, south of Aswan the Nile is constrained by a narrower river valley than in the northern areas where recent geomorphological investigations have identified a wide range of movement. Although the actual precise location and channel of the Nile may therefore have varied, it would have remained within the Nile valley gorge shown on the Survey of Egypt map from 1944.

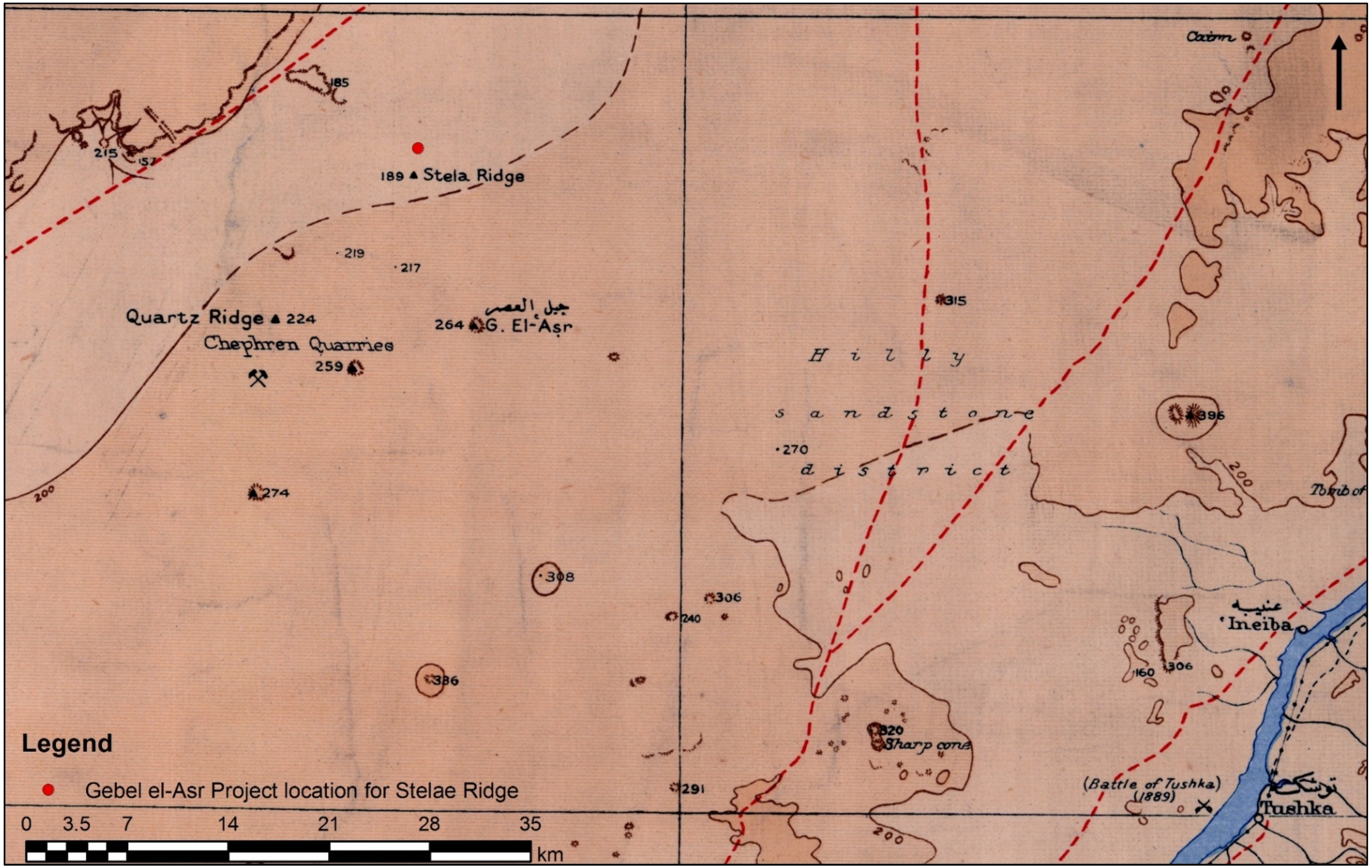


Fig 4.9: Survey of Egypt map of Aswan (Sheet 11) from 1944 showing the Gebel el-Asr quarries and Stelae Ridge in relation to the Nile. The original scale is 1:500,000. (Survey of Egypt Aswan Sheet 11 CAMEL reference number 1013711_Aswan_sheet_11_1944)

After the Old Kingdom varying depths of aeolian deposits built up on top of the duricrust, with minimal deposition in open areas and deeper drifts against and within archaeological and natural features. Without extensive geomorphological investigation it is impossible to say precisely where the deeper aeolian deposits might be located, but given the flat nature of the landscape in general and minimal aeolian deposition in open areas, deeper areas of aeolian deposition are likely to be highly localised. In general there is unlikely to be a great difference between the topography of the landscape in the present day and that in the Middle Kingdom, with the exception of the recent cultural features associated with the Sadat (or main) canal and the Tushka Project.

4.5. Modern alterations to the landscape

There have been a number of alterations to the landscape around Stelae Ridge and in the Gebel el-Asr region generally. The area is now engulfed in modern activity and this has resulted in considerable damage to some of the archaeological sites, including Stelae Ridge.[228] The effect of modern construction upon the site and the precise changes to the landscape it has engendered are recorded on a series of satellite images dating from 1968 until 2013.

4.5.1. The landscape in the CORONA photographs

The earliest satellite imagery to show Stelae Ridge and the Gebel el-Asr region are CORONA high resolution satellite photographs taken in 1968.[229] All the imagery of the Gebel el-Asr area was from the CORONA KH-4B project, from missions 1105 and 1107. Only image DS1105-2235DF077 showed the site at Stelae Ridge, but DS1105-2235DF076 and DS1105-2235DF078 showed the area around the site, including the Gebel el-Asr quarries.

In general, the CORONA images (Fig 4.10 and Fig 4.11) reveal something of the openness, flatness and emptiness of the desert landscape prior to the construction of the Gebel Uweinat Road and the Tushka Project. It is noticeable how flat the landscape is; prominent hills and other topographic features appear very clearly. There is very little evidence of any human activity in the Gebel el-Asr area or around Stelae Ridge, not even any roads.

---

[228] See Shaw (*et al.* 2010, 302–303) and Storemyr (2009, 114) for the effect of modern activity upon the site.
[229] For technical specifications of CORONA imagery see Chapter 2, section 2.2.1.

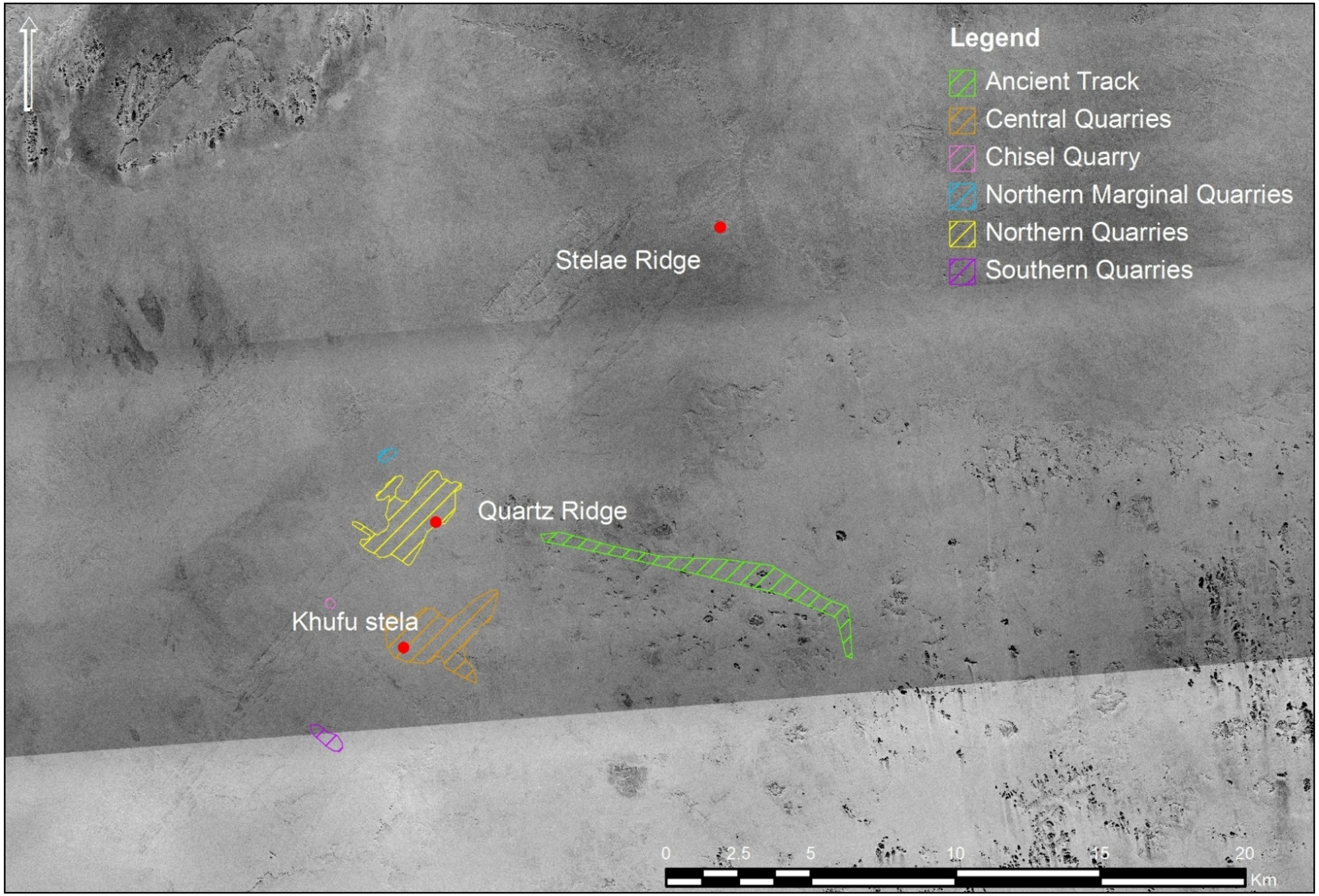


Fig 4.10: The Gebel el-Asr quarrying region from 1968 KH-4B CORONA images 1105-2235DF076-078, from CAST, University of Arkansas/USGS. The photographs are not mosaicked, so the CORONA strips are clearly visible.

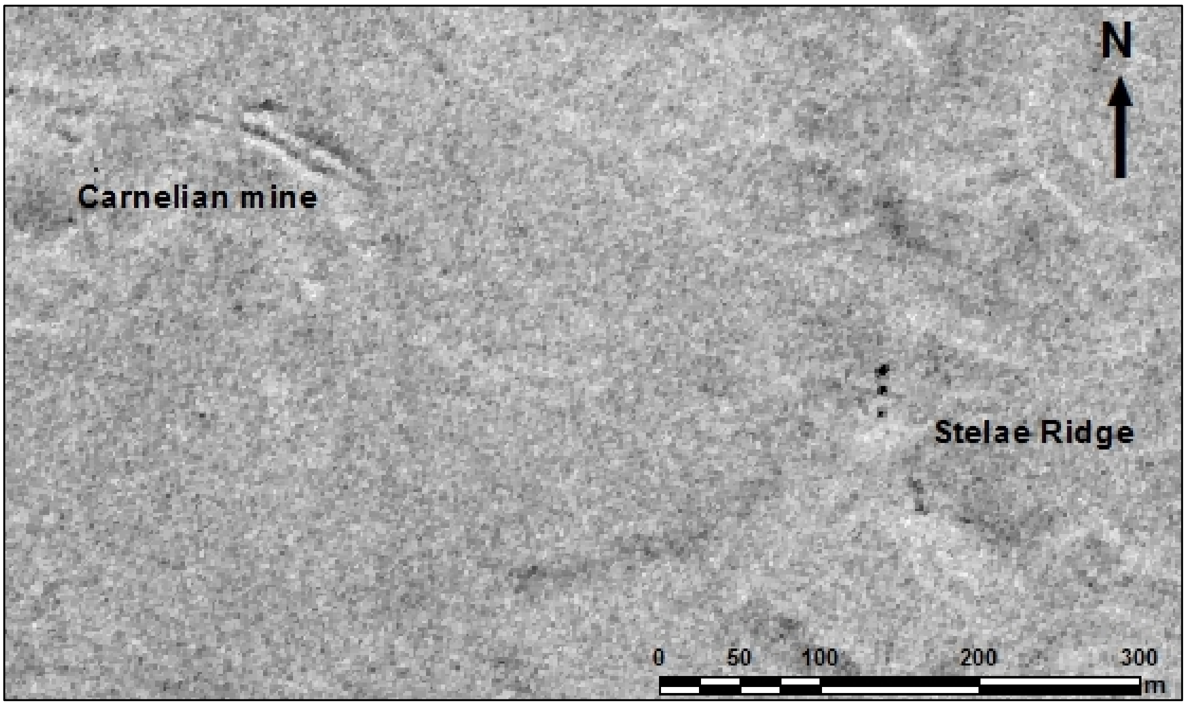


Fig 4.11: Stelae Ridge from the 1968 CORONA image 1105-2235DF077, obtained from the Centre for Advanced Spatial Technology, University of Arkansas/USGS.

4.5.2. The changing landscape in the Landsat images 1972 to 2013

Landsat satellite imagery shows the Gebel el-Asr area from 1972 to 2013.[230] In the subsequent figures, Gebel el-Asr Project survey data has been overlaid onto the Landsat images to provide an indication of the location of archaeological features and some reference points. Throughout the images metalled roads typically appear as black lines, often with lighter marks on each side. Unmetalled roads appear light. Water also appears dark and canals appear as dark, if filled with water; or light, if empty.

Landsat 1: 1972

The earliest Landsat imagery obtained dated from 1972[231] and comprised four bands taken with the Multi-Spectral Scanner (MSS) sensor of the first Landsat satellite. The 1972 Landsat imagery shows the same open unmodified landscape as the CORONA images (Fig 4.13). The low resolution (60m) of the imagery means that it is not possible to differentiate the Stelae Ridge cairns or any other archaeological features from the surrounding landscape on any of the MSS bands.

---

[230] For technical specifications of Landsat imagery see Chapter 2, section 2.2.2.
[231] Landsat 1, path number 188; row number 44; image designation p188r44_1m19721109.

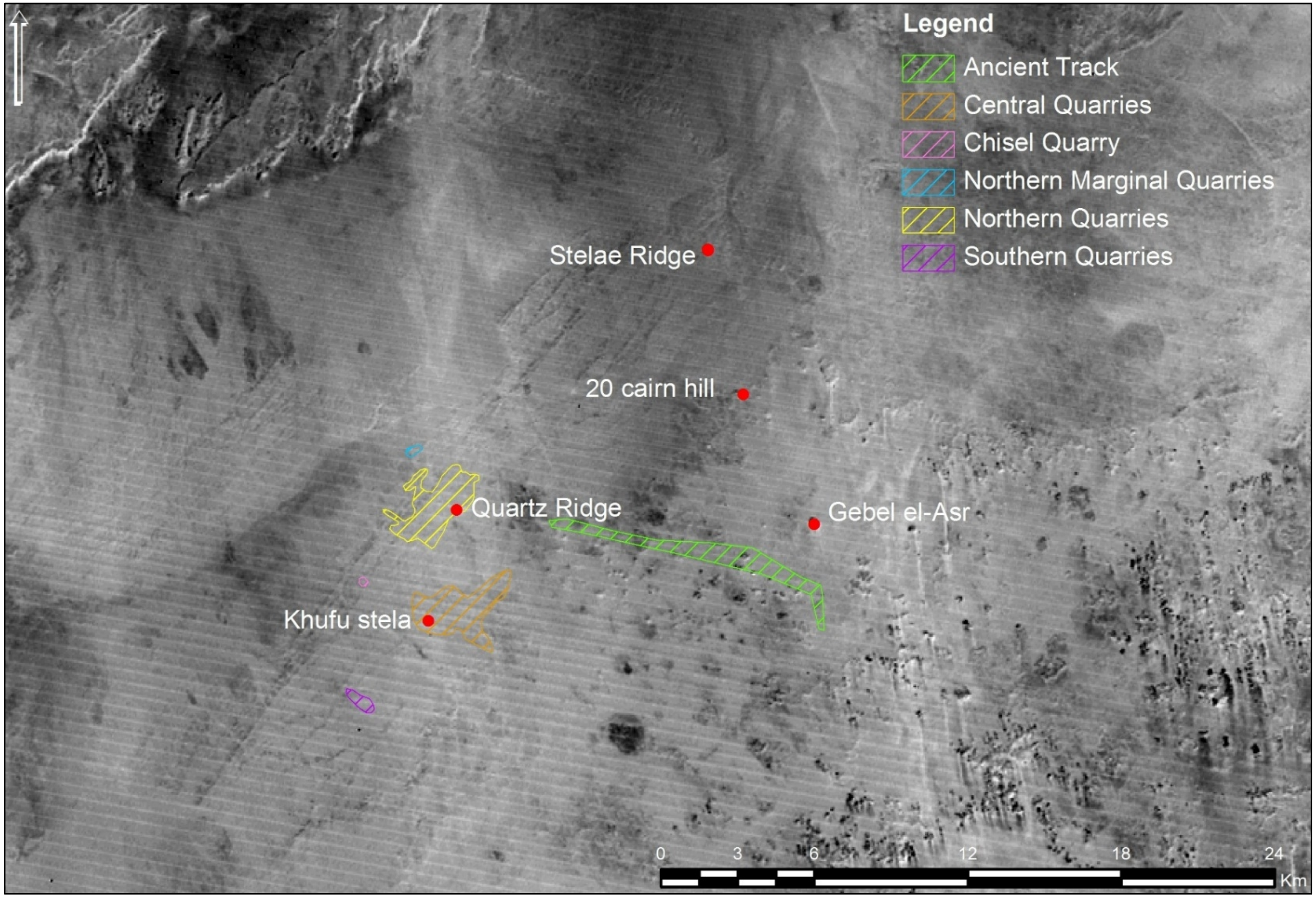


Fig 4.13: The Gebel el-Asr region from 1972 Landsat 1 MSS image LM11880441972296AAA02, Band 4, Infra-red with 60m resolution. Archaeological locations from the Gebel el-Asr Project survey data (Satellite image from the USGS).

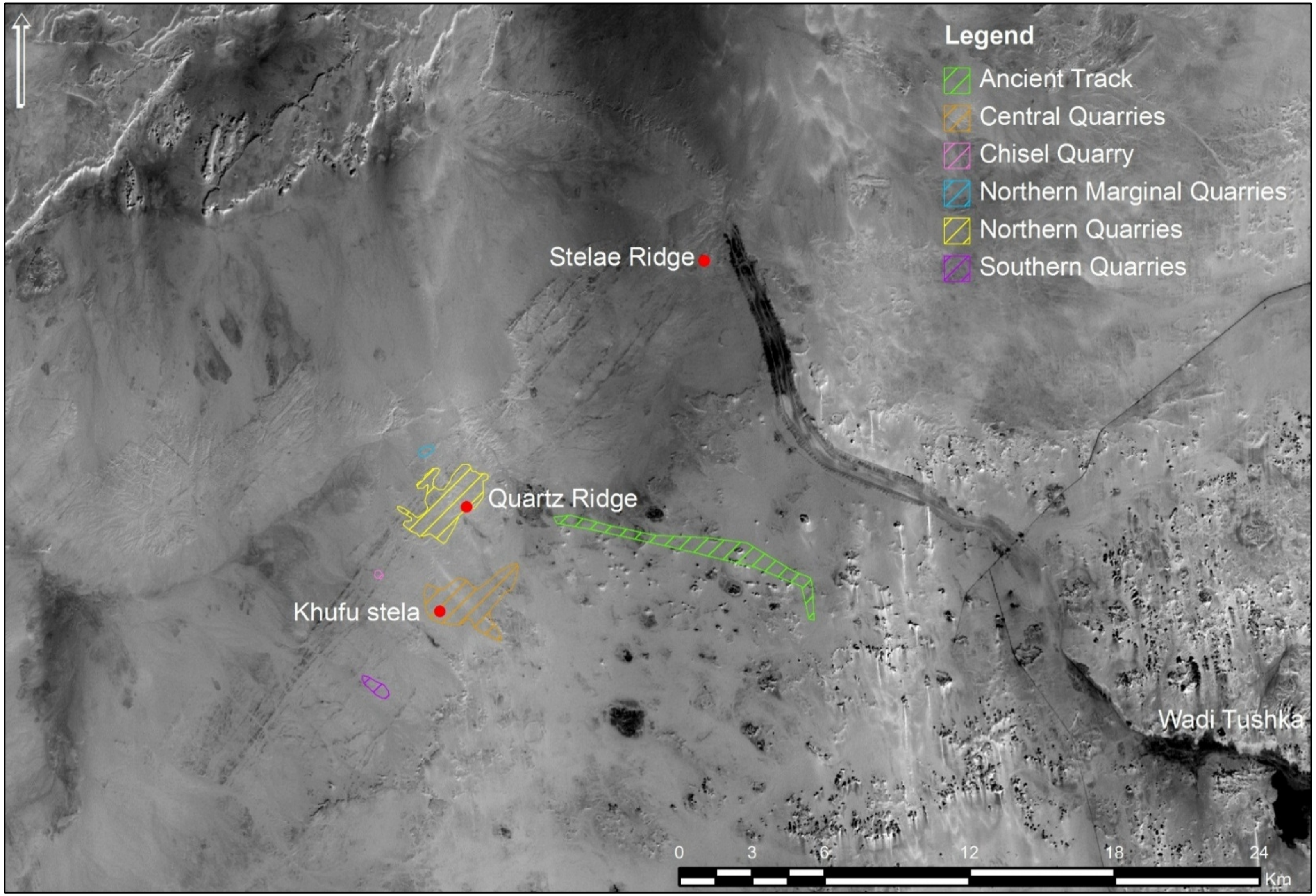


Fig 4.14: The Gebel el-Asr area from 1984, Landsat 5 TM image LT51750441984305XXX01, band 7 (SWIR), 30m resolution. Archaeological locations from the Gebel el-Asr Project survey data (Satellite image from the USGS).

The Landsat image does reveal two major landscape features in the vicinity of Stelae Ridge. The first is the Gebel el-Asr itself *c.*11.5km south-east of Stelae Ridge. The second is a ridge *c.* 5.8km south of Stelae Ridge. This ridge is relatively prominent in the landscape and several cairns were observed upon it by the author during the 2012 survey, although the ridge was not visited. This ridge was initially identified as Engelbach's '20 cairn hill' and is referred to as such throughout the rest of this chapter.[232]

Landsat 5: 1984

The Thematic Mapper (TM) sensor of Landsat 5 provides 30m resolution imagery of Stelae Ridge from 1984.[233] Examination of the seven electromagnetic bands recorded by the TM sensor has shown that Band 3 red, Band 4 near-infrared, and Band 7 short-wave infrared provide the clearest rendition of the landscape and anthropogenic features. Fig 4.14 shows the features around Gebel el-Asr and Stelae Ridge visible to short-wave infrared (Band 7) sensors of the TM. In contrast to the largely unmodified landscape shown in the CORONA and Landsat 1 imagery, by 1984 a large linear canal or spillway had been built and ran from just east of Stelae Ridge towards Wadi Tushka. This is the Sadat canal, hereafter known as the 'main canal', because of its primary role in the later Tushka Project. The road between Aswan and Abu Simbel is clearly visible in the eastern part of the image, but the Gebel Uweinat road, which passes close to Stelae Ridge, is not defined in the same way.

More detailed analysis of band 4 (near infra-red) of the same Landsat image (Fig 4.15) reveals that there are faint traces running roughly parallel with the canal, some 500m from it, along its southern and western sides. The feature delineated by these traces is on the same alignment and in roughly the same location as the Gebel Uweinat road, but does not have the same clarity as the tarmac road between Aswan and Abu Simbel in Fig 4.14. It is probably an unmetalled forerunner of the modern tarmac Gebel Uweinat road and was perhaps created and used by the builders of the nearby canal.

---

[232] Problems with the identification of this feature as 20 cairn hill are discussed in more detail in Chapter 3, section 3.3.2 and 3.7.3.
[233] Landsat 5, Path 175, Row 44, image LT51750441984305XXX01.

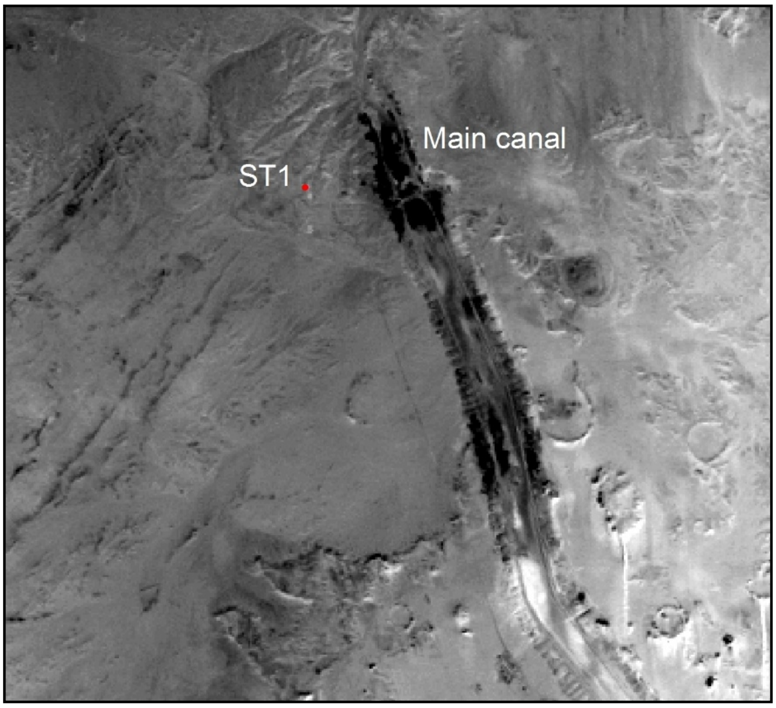


Fig 4.15: Detail of the Landsat 5 1984 TM image LT51750441984305XXX01, Band 4 (NIR). Point ST1 is located at Stelae Ridge and taken from the author's 2012 survey data. (Landsat image from the USGS).

Evidence of the construction of the canal is visible in the spoil heaps mounded along its sides. At 30m resolution, Fig 4.15 has too large a pixel size to show the individual cairns at Stelae Ridge. A lighter polygonal area immediately south of ST1 is probably to be identified as the polygonal area of modern disturbance recorded by both the Gebel el-Asr Project and the 2012 survey, in the area where Engelbach recorded the southern group of cairns.[234] The feature is roughly the right size, allowing for the pixel size of the satellite image, and in the correct position. If this identification is correct it would suggest that the damage to the site, particularly the demolition of the southern group of cairns, began prior to this 1984 image and was probably associated with the nearby construction works on the main canal.

Landsat 7: 1999–2000.

Subsequent Landsat 5 TM imagery[235] from the 1980s and early 1990s shows little change to area. The earliest imagery to show the Gebel Uweinat road as a metalled surface is Landsat 5 TM imagery from 1998.[236]

[234] Engelbach's record of the archaeological features is discussed in Chapter 3, section 3.2. The Gebel el-Asr Project survey data and the 2012 survey are discussed in Chapter 3, section 3.6–3.7.
[235] All available Landsat images were checked either on EarthExplorer or downloaded as images.
[236] Landsat 5, Path175, Row 44, image LT51750441998039XXX01.

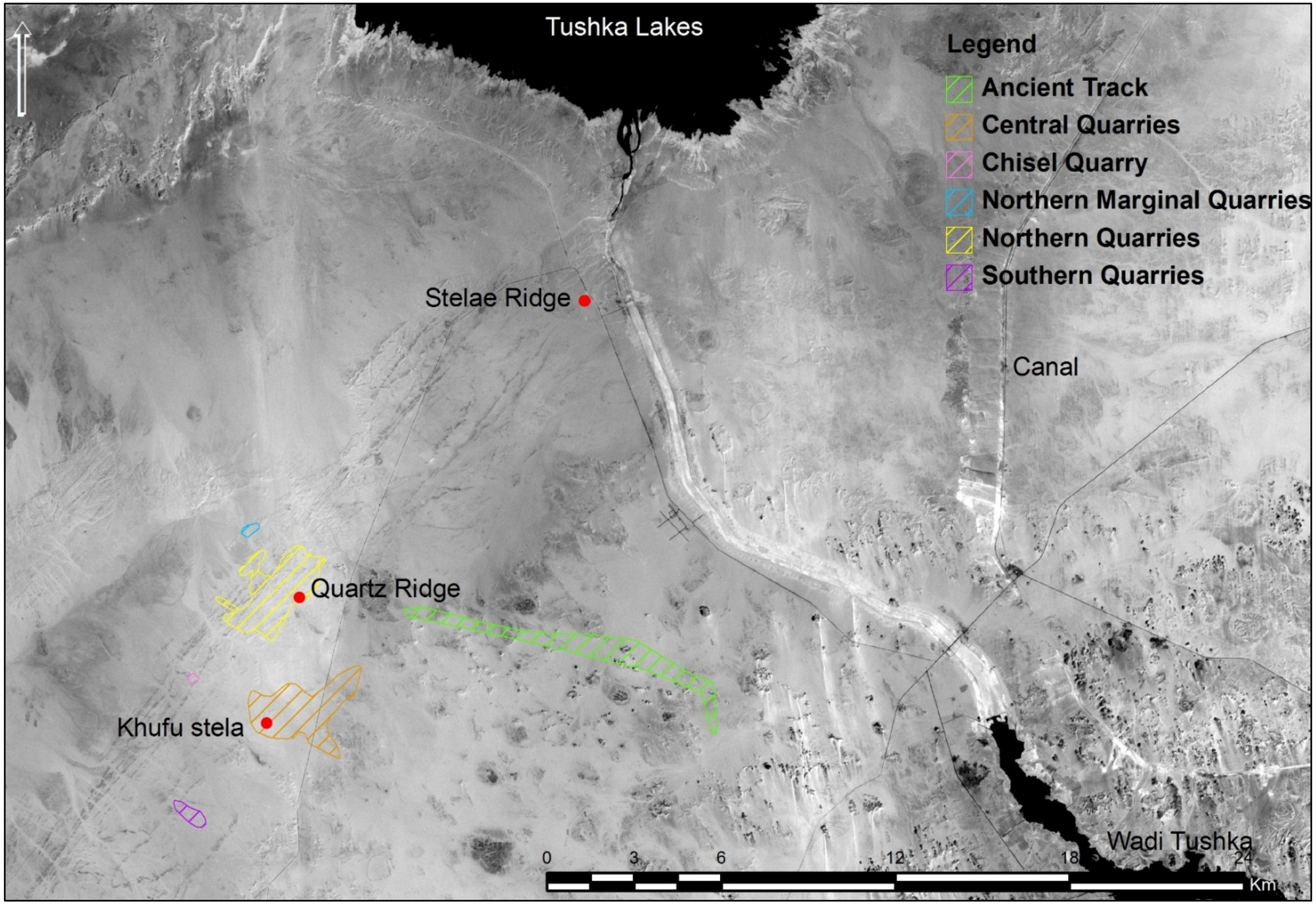


Fig 4.16: The Gebel el-Asr area from the 1999 Landsat 7 ETM+ image LE71504419992420EDC00, 15m resolution panchromatic band. Archaeological locations from the Gebel el-Asr Project survey data (Satellite image from the USGS).

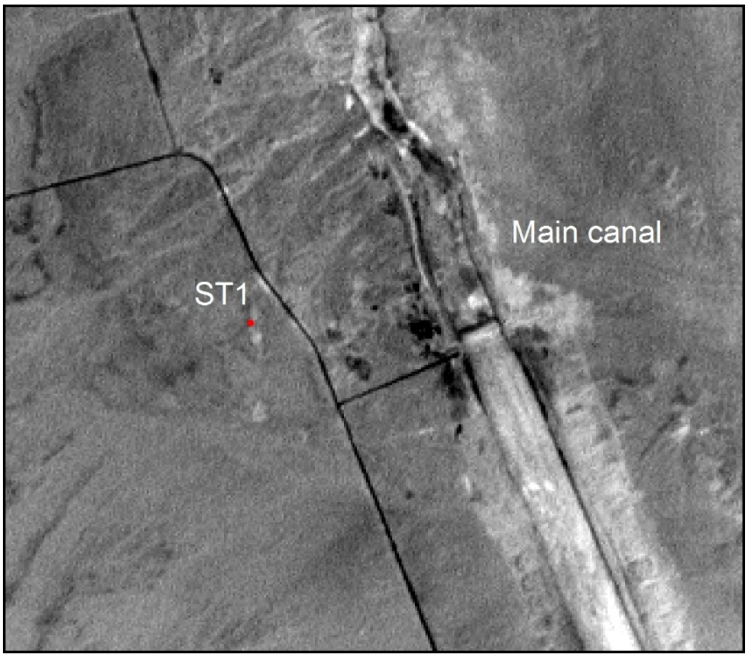


Fig 4.17. Detail of the 1999 Landsat 7 ETM+ image LE7150441999242EDC00 15m resolution panchromatic band showing the lighter areas of modern disturbance around Stelae Ridge. (Data available from the USGS).

Fig 4.16 shows the Gebel el-Asr area from a year later when Landsat 7 took an Enhanced Thematic Mapper Plus (ETM+) image,[237] which included a 15m resolution panchromatic band The figure shows that the main canal had been completed and overspill from Lake Nasser had created the man-made Tushka Lakes in the northern part of the image. The Gebel Uweinat road is also clearly visible to the west of main canal and, since it appears similar to the Aswan to Abu Simbel road, had presumably been metalled by this date. A secondary canal is also shown under construction to the east of the main canal and west of the road between Abu Simbel and Aswan. This canal formed an early part of the Tushka Project.

Fig 4.17 shows the area around Stelae Ridge in greater detail. The higher resolution of the ETM+ panchromatic band confirms that the lighter polygonal area south-east of ST1 is the area of modern disturbance recorded in later surveys. Two additional light areas, one to the north and the other to the south of Stelae Ridge, are also visible and are probably other areas of modern disturbance noted during the Gebel el-Asr Project survey.

A colour Landsat 7 image (Fig 4.18) from 2000,[238] reveals the development of the Tushka Project canals in more detail. It shows the continuing development of the secondary canal, visible in the image from 1999 and the beginning of construction on a new tertiary canal. The continuing development of the Tushka Project canals during the 2000s was monitored by the Gebel el-Asr Project.

---

[237] Landsat 7, Path 175, Row 44, image LE7150441999242EDC00.
[238] Landsat 7, Path 175, Row 44, image p175r044_7f20000901_z36_ps742.

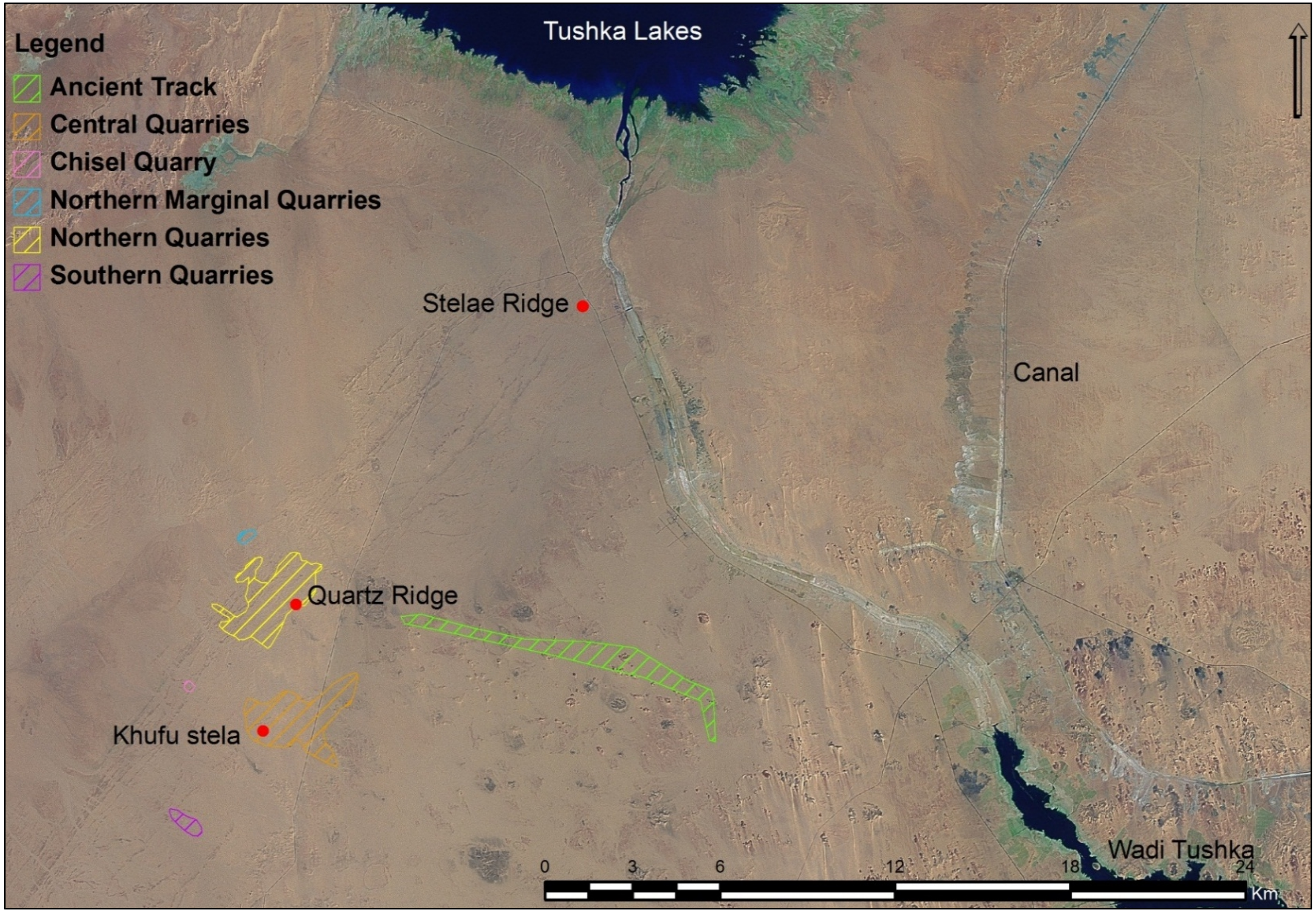


Fig 4.18: Colour image of the Gebel el-Asr area taken from the Landsat 7 ETM+ image p175r044_7f20000901_z36_ps742 from 2000. Archaeological locations from the Gebel el-Asr Project survey data (Satellite image from the USGS).

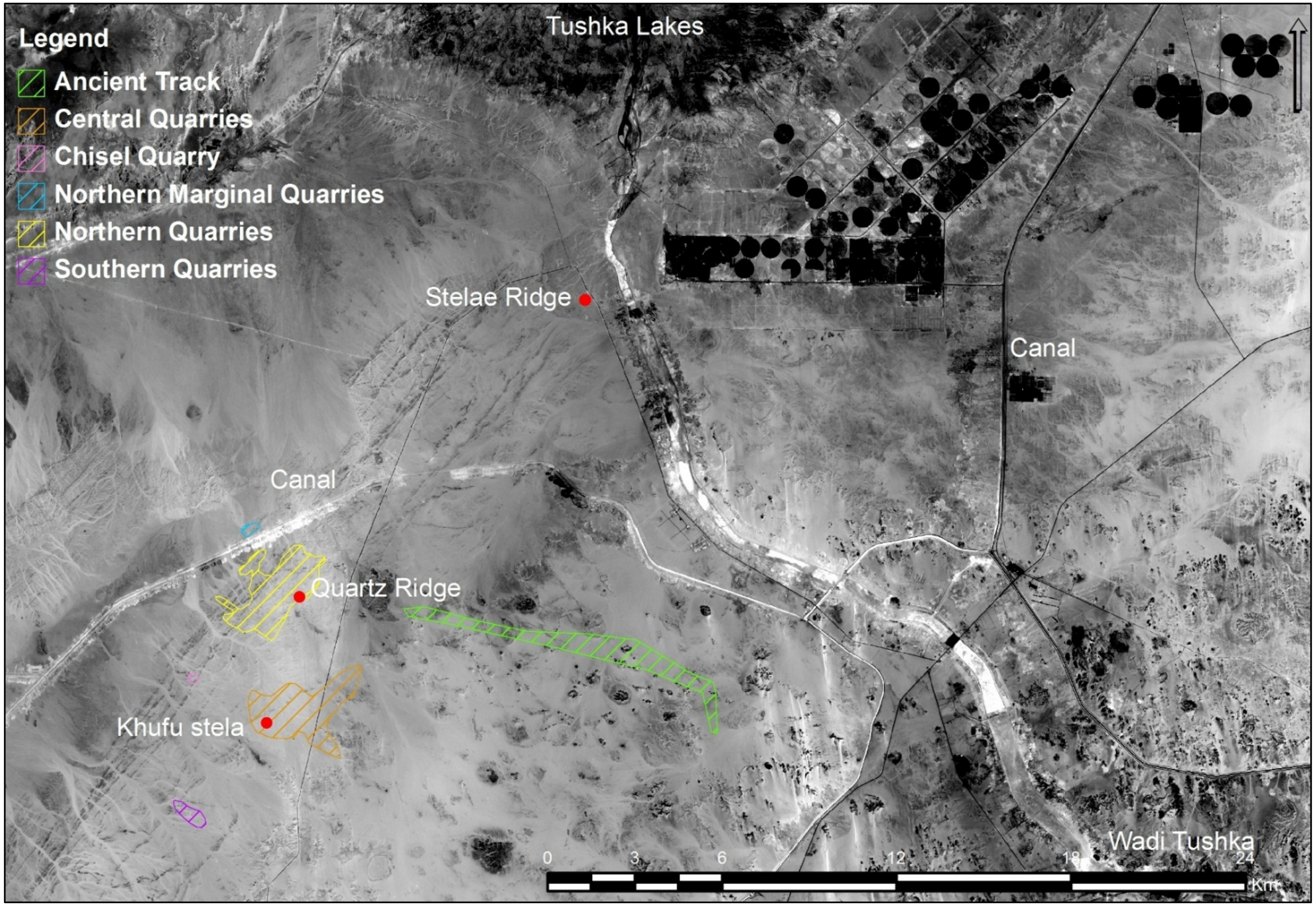


Fig 4.19: Landsat 8, 15m resolution panchromatic image LC81750442013144LGN00 of Gebel el-Asr, taken in 2013. Archaeological locations from the Gebel el-Asr Project survey data (Satellite image from the USGS).

Landsat 8: 2013.

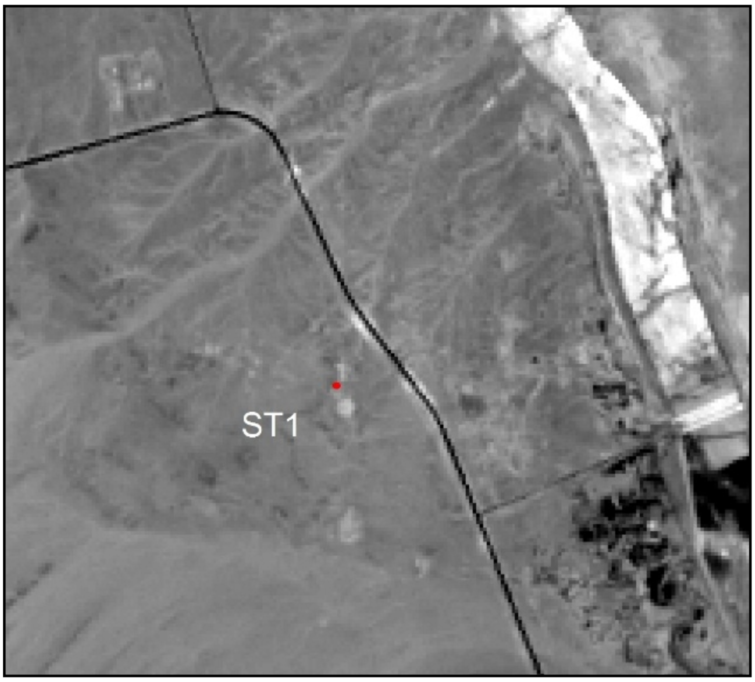


Fig 4.20: Detail of Landsat 8 image LC81750442013144LGN00 15m resolution panchromatic band from 2013, showing the areas of modern disturbance around Stelae Ridge. (Satellite image from the USGS).

The most recent satellite image of the site was taken in 2013 by the Landsat 8 satellite OLI/TIRS system.[239] The 15m resolution panchromatic band (Fig 4.19) shows the many anthropogenic features present in the earlier satellite imagery. The tertiary canal, upon which construction had only just been initiated in 2000, is shown continuing across the quarrying area and turning south-west between the Northern Quarries and the Northern Marginal Quarries. To the north, the Tushka Lakes had shrunk considerably, perhaps due to continuing evaporation and a lack of fresh water ingress along the main canal from Wadi Tushka.

A large number of circular features are also visible in the image to the east of Stelae Ridge between the main canal and the secondary canal. Based on observations made during the 2012 Survey, these are associated with the Tushka Project agricultural scheme to create farmland from the desert.

A detail of the same image (Fig 4.20) shows how the improved sensors of the Landsat 8 satellite provide more details of the Stelae Ridge area. The areas of modern disturbance to the north and south-east of ST1 are very clear. Some patchy lighter areas to the west of Stelae Ridge might reflect the location of the large mine, associated cairns and other features, although the pixel size makes it difficult to identify these features with any certainty.

---

[239] For the sensors on the Landsat 8 satellites see http://landsat.gsfc.nasa.gov/?p=3186, last accessed 27 August 2013.

4.6. The SRTM as a model of the Middle Kingdom landscape

The SRTM did not contain the defects present in the ASTER GDEM2. The sensitivity tests suggested it will produce reasonably accurate visibility analysis, particularly for observer heights within the range for Middle Kingdom adults, perhaps even better than those anticipated from the ASTER GDEM2 at Gurob.

The climatic evidence suggests the modern environment is reasonably similar to the Middle Kingdom environment. While the area probably experienced higher rainfall in the Middle Kingdom with easier access to water and slightly more vegetation, particularly after rains and around wells, the total quantity of vegetation is likely to have been limited. There would certainly not have been enough water to sustain sufficient vegetation to obscure visibility, while localised greenery around wells might even have made them more visible. The slightly more hospitable climate could have affected how the landscape was perceived or how people ‘felt’ about it, but the evidence suggests there is no need to consider modifications to the visibility analysis for ‘heavy’ vegetation or other substantial environmental obstructions to visibility.

The Landsat imagery from the last 30 years shows a succession of alterations and modifications to the original open landscape visible in the CORONA and Landsat 1 images. Beginning with the construction of the main canal in the early 1980s, followed by the Uweinat road, the later canals of the Tushka Project and Tushka Lakes there have been a number of large scale alterations to the physical landscape around the site. These have been accompanied by small scale, local alterations, such as the damage to the Stelae Ridge cairns and the areas of disturbance around them.

Alternative DEM, such as the ASTER GDEM2, available to this project all date from a similar period and therefore also include the same landscape alterations in their models. The lower resolution of the SRTM may obscure some of the smaller modern features visible on the ASTER GDEM2, but the larger ones remain. Theoretically it would be possible to alter the SRTM to remove the large modern alterations to the physical landscape, but there are several problems with this. While the satellite imagery indicates whether an anthropogenic feature is generally lower or higher than the original ground surface, it does not reveal by how much. Quantifying the precise amount by which the cell values should be changed is therefore very difficult. Furthermore, it is possible that in attempting to alter the SRTM to resemble the landscape shown in the CORONA and Landsat 1 images, genuine topographic features would be removed together with modern anthropogenic alterations. For example, along the edges of the main canal are a series of features comprising spoil heaps from the canal’s construction. These are higher than the surrounding landscape and, given their origin, would be removed from the modified SRTM as modern alterations to the landscape. It is possible that some of these spoil heaps may obscure genuine rises, ridges and hills present before the construction of the canal, and removing them would therefore be as inappropriate for any reconstruction of the Middle Kingdom landscape as the presence of the main canal. Indeed, analysis revealed that the spoil heaps obscured part of Engelbach’s original ’20 cairn hill’. Removing them from the SRTM would have prevented this discovery during the visibility analysis, as well as unnecessarily eliminating a significant topographic feature of the original landscape.[240]

There are also obvious problems associated with attempting to ‘strip away’ the modern landscape to reveal the ‘original’ form.[241] The assumption that we can ‘strip away ‘distorting’ factors . . . to reveal a pristine prehistoric landscape is clearly problematic (Brück 2005, 54)’ since the landscape is always changing and does not possess an ‘original form’. Furthermore, a modified SRTM could lead to the false impression that it is somehow more ‘true’ to the Middle Kingdom landscape, when it could be just as ‘false’ as the unmodified SRTM if genuine landforms are removed or original landforms cannot be reconstructed.[242]

For all these reasons, the modern features will be left in the SRTM for the visibility analysis, with the proviso that any conclusions relating to the landscape around them must take their presence into account. These modern features are a part of the modern landscape and reflect its recent history. It is true that they will inevitably affect the visibility analysis in, possibly unknowable, ways that may not be applicable to the Middle Kingdom experience of visibility, but any interpretation is limited and partial because the available evidence is limited. Overall it was felt preferable to leave the modern features as explicit evidence of the differences between the modern landscape and the Middle Kingdom landscape, rather than create the false impression of an ‘accurate’ Middle Kingdom landscape by removing them.

---

[240] For the identification of 20 cairn hill from the results of the visibility analysis see Chapter 6, section 6.1.1.

[241] These points are made very clearly in Chadwick (2004, 21–23) and Thomas (2001; 2004, 198–201).

[242] Similar arguments have been made against virtual reality models, see Gidlow (2000) and references therein.

5. Systematic GIS visibility analysis of Stelae Ridge

GIS visibility analysis was chosen as an analytical tool to investigate the landscape context of the Stelae Ridge cairn-courts, in order to determine whether this type of visibility analysis could be a useful tool for generating new data for the interpretation of similar non-formal structures at other sites.[243] The ArcGIS visibility toolset provided the means to systematically assess the visibility of the eight Middle Kingdom cairn-court structures on Stelae Ridge, generating data which revealed similarities and differences between the visibility and visual relationships of individual structures and groups of them. Other, probably similar, structures in the area of Stelae Ridge, could not be included because no record was made of their position and layout in the past and they have not survived *in situ* to be recorded in detail by the recent investigations discussed in Chapter 3.

The detailed method, information on the GIS and types of visibility analysis employed here, are discussed in Chapter 2, particularly section 2.4–2.7. Chapters 3 and 4 present the results of the preliminary research undertaken preparatory to this systematic visibility analysis. Chapter 3 considers the archaeological context of the Stelae Ridge cairn-courts, including their location and layout. Chapter 4 presents the SRTM, the DEM chosen for this visibility analysis, and an assessment of how far it provides a reasonable model of the Middle Kingdom landscape.

This chapter contains the results of the systematic visibility analysis using cumulative viewshed and observer points analysis to identify from where the cairn-courts could be seen and what could be seen from them. Different analyses were undertaken to assess visibility of the courts and the cairns, and viewsheds for individual structures, and groups of them, were extracted from these analyses and quantified to establish their sizes. The viewsheds are not presented here as a simplistic representation of the Middle Kingdom or modern experience of visibility, but as data which reveals patterns of visibility between the individual structures and groups of them. It is the interpretation of the meaning of these patterns in the context of archaeological and textual evidence from the site and elsewhere, undertaken in Chapter 6, which is of significance for improving understanding of the Stelae Ridge structures.

This Chapter 5 also contains the results of tests undertaken to assess the impact of various parameters upon the visibility analysis, including the use of azimuths to model the impact of the cairns upon visibility from the courts and the target offset used to represent the cairns.

---

[243] Chapter 1, section 1.4 discusses the use of visibility analysis in the interpretation of non-formal structures at quarrying and mining sites and section 1.5 of the same chapter explains the reasons why Stelae Ridge was chosen as a case study.

Other limitations upon the visibility analysis, which could not be tested, are identified in section 5.5. These include various aspects of the SRTM DEM, including the modern anthropogenic landscape features present within it that were discussed in Chapter 4, section 4.5. To remind the reader of the presence of these modern features and focus attention on the shape and size of the viewsheds, which reflect the patterns of visibility for the different structures, the figures in this chapter show the viewsheds overlying the SRTM DEM.

5.1. Visibility analysis of the courts

Systematic visibility analysis of the courts was undertaken to establish what an observer in the courts could see of the landscape around Stelae Ridge and from where the courts could be seen.

5.1.1. Cumulative viewshed analysis of the courts

The results of the projective and reflective cumulative viewshed analysis of the courts are quantified in Table 5.1. The projective cumulative viewshed is shown in Fig 5.1 and the reflective cumulative viewshed in Fig 5.2.

Table 5.1: Area of the projective and reflective cumulative viewsheds for observer points OB1-OB8 in the courts at Stelae Ridge

Number of courts	Projective cumulative viewshed			Reflective cumulative viewshed		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)		Number	Area (km^2)	
1	304	2.27	1.84	442	3.30	1.91
2	385	2.88	2.33	543	4.06	2.35
3	213	1.59	1.29	382	2.86	1.66
4	340	2.54	2.06	650	4.86	2.82
5	821	6.14	4.98	7355	54.98	31.87
6	1068	7.98	6.47	6202	46.36	26.87
7	2338	17.48	14.17	3847	28.76	16.67
8	11029	82.45	66.85	3660	27.36	15.86
Total (TVA)[244]	16498	123.33	100.00	23081	172.54	100
<5	1242	9.28	7.53	2017	15.08	8.74
>=6	14435	107.91	87.50	13709	102.48	59.40
>=5	15256	114.04	92.47	21064	157.46	91.26

[244] TVA is the 'total visible area', as defined in Chapter 2, section 2.5. In the projective cumulative viewshed this is the area visible to at least one of the courts. In the reflective cumulative viewshed it is the area where at least one court is visible. The total visible area of both projective and reflective cumulative viewsheds is shown in Fig 5.4.

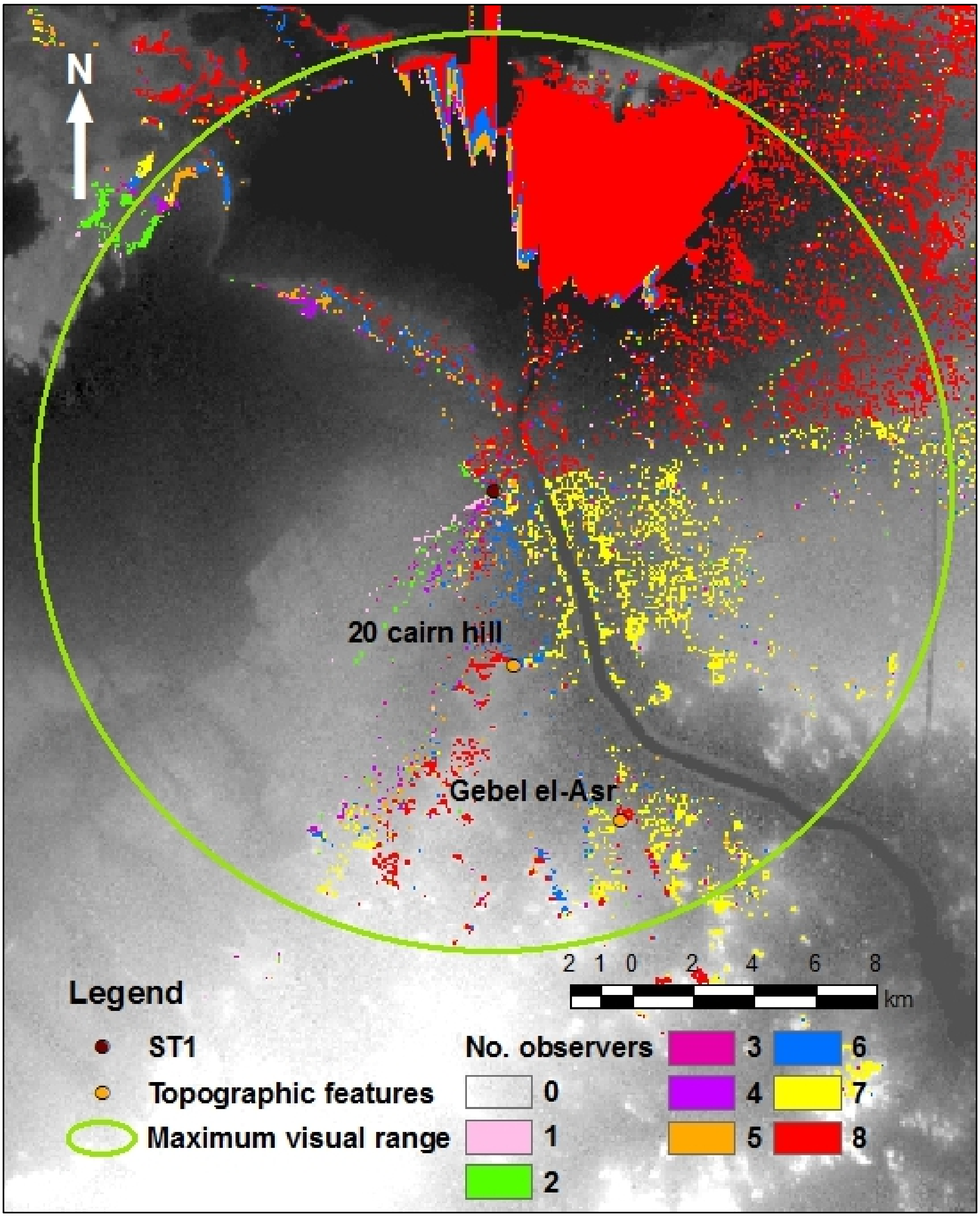


Fig 5.1: Results of the projective cumulative viewshed analysis showing how many observers, located in the courts of cairns I to VIII, could see the landscape around Stelae Ridge. Maximum visual range represents an area 15km radius from ST1. Cumulative viewshed shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

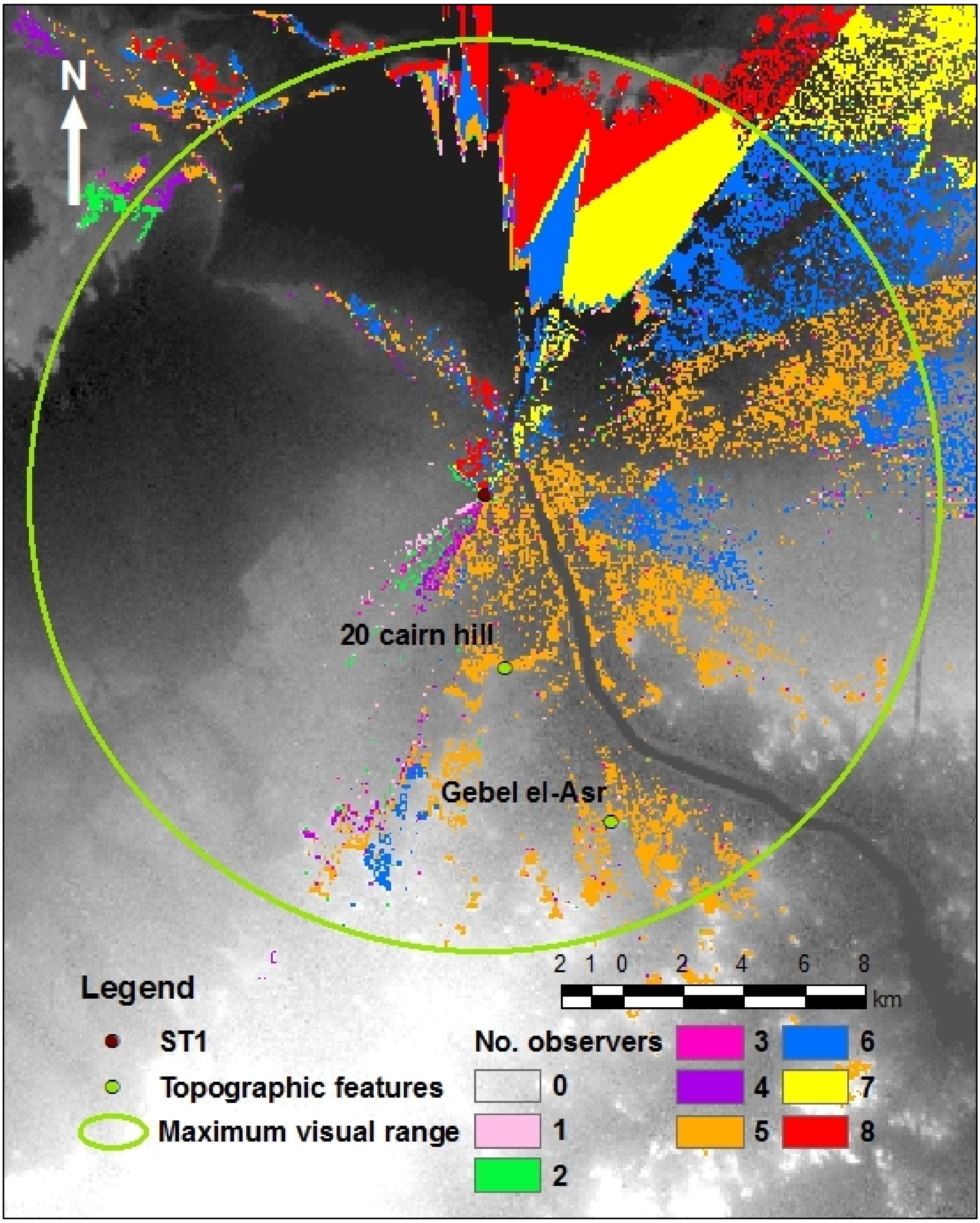
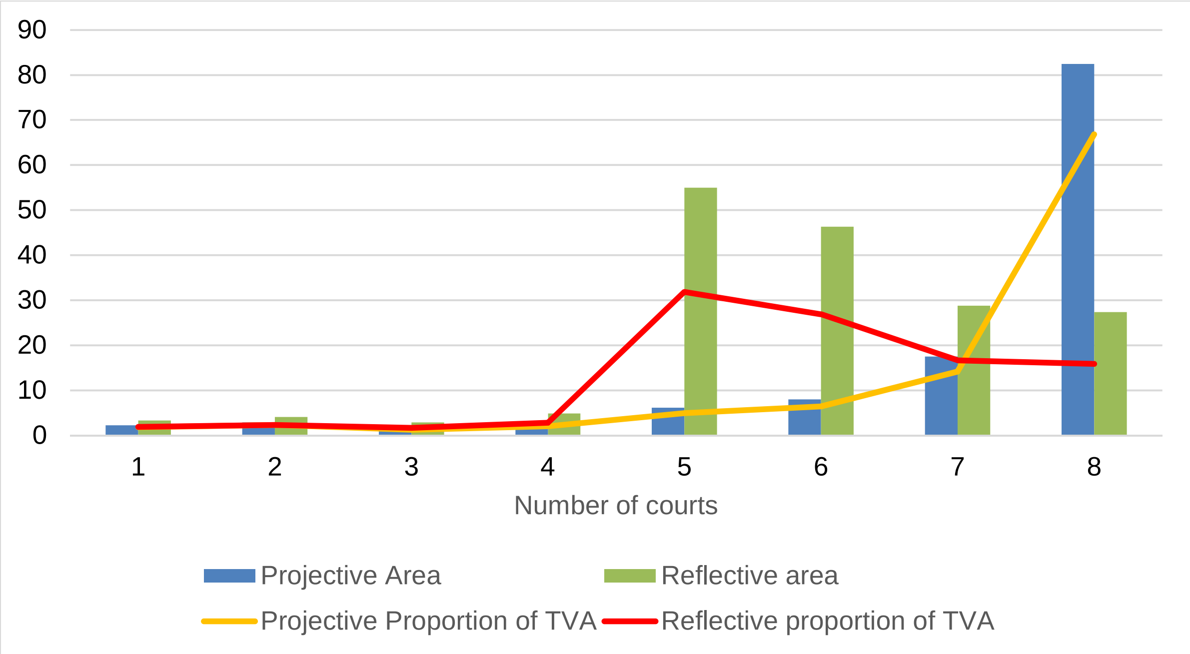


Fig 5.2: Results of the reflective cumulative viewshed analysis showing how many observer points, located in the courts of cairns I to VIII, could be seen from the landscape around Stelae Ridge. Cumulative viewshed shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data available from the USGS).

Chart 5.1. The areas of the projective and reflective cumulative viewsheds by number of courts. Bars show area in km^2 and lines show percentage of the total visible area (Data taken from Table 5.1).



Cumulative viewshed size is very consistent in both projective and reflective cumulative viewsheds for up to and including to four courts (Chart 5.1). The very small area occupied by these cumulative viewsheds can be seen in Fig 5.3, which also shows how dispersed the areas are.[245] The observer points analysis later revealed that this was due to the very similar viewsheds of the five courts on the southern ridge.[246] The projective cumulative viewsheds increase in size with the number of courts up to 82.45 km^2, the area visible from all eight courts. By contrast, the largest reflective cumulative viewshed is the area where five courts are visible at 54.98 km^2 and viewshed size then decreases as the number of courts increases.

[245] The only area with relatively concentrated projective and reflective visibility of fewer than five courts is located to the south-west of Stelae Ridge. This may be associated with the use of the azimuths and is considered in section 5.2.
[246] For the observer points analysis see section 5.1.2.

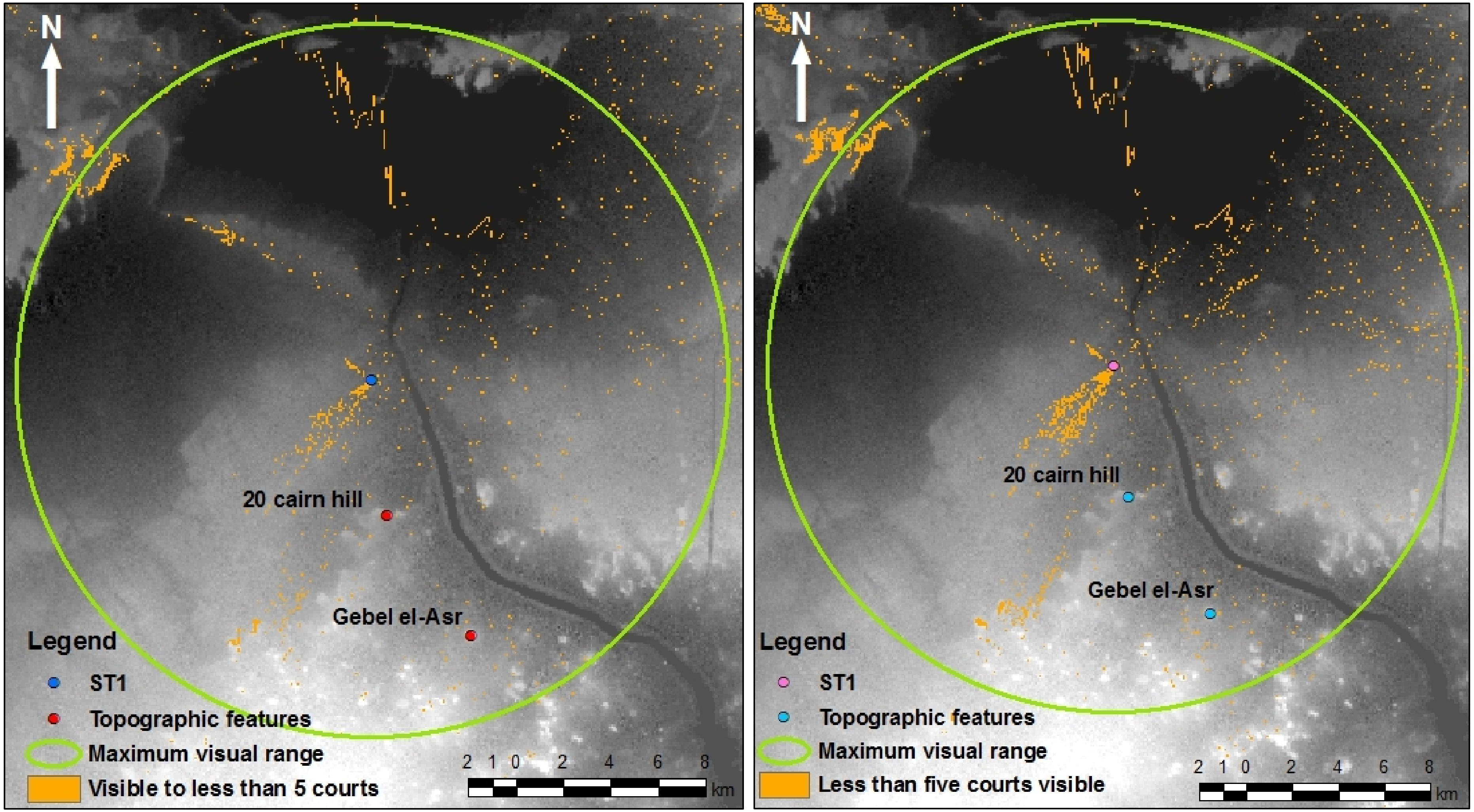


Fig 5.3: a) The projective cumulative viewshed visible to less than five courts (left), and b) the reflective cumulative viewshed where fewer than five courts would be visible (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

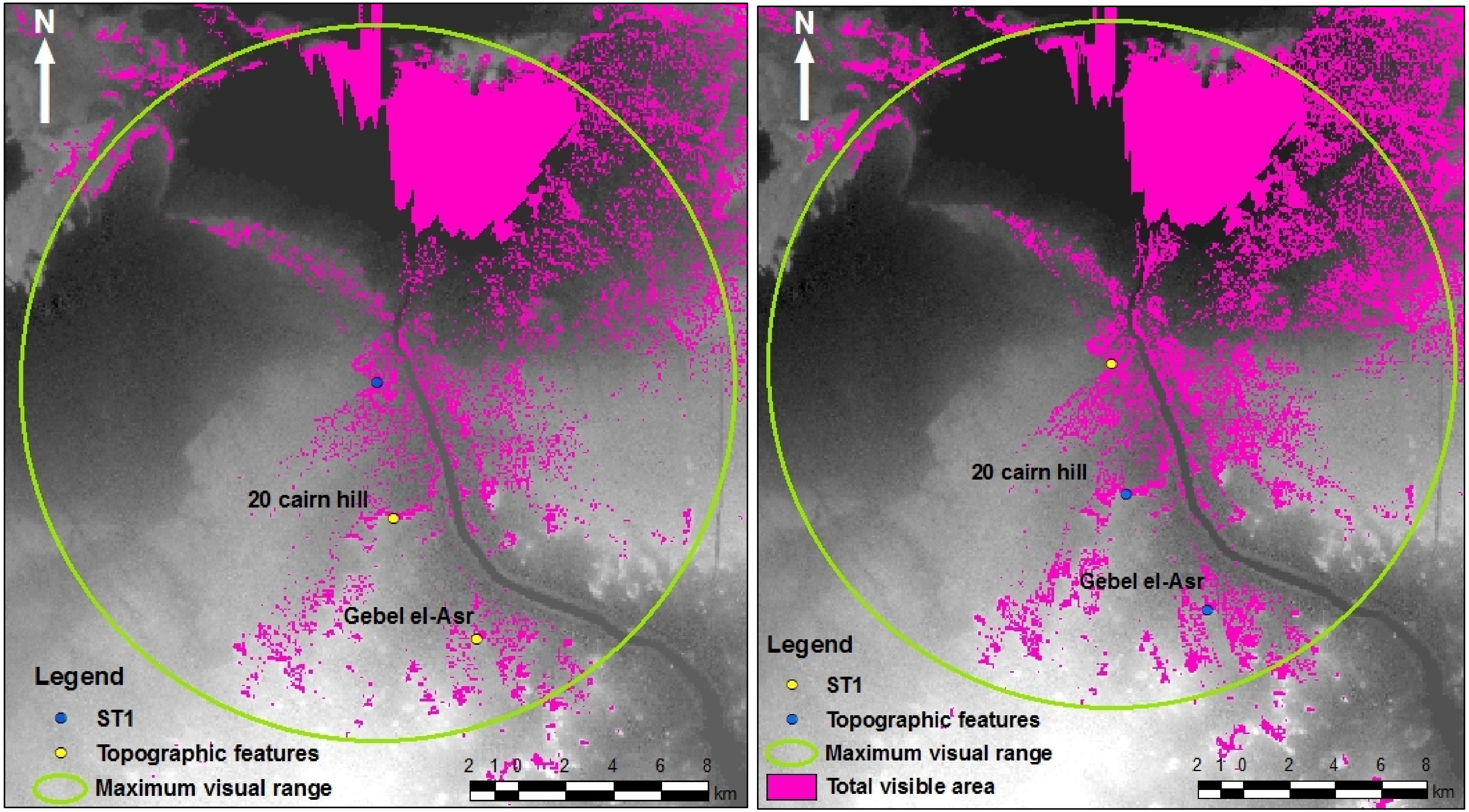


Fig 5.4: The total visible area of a) the projective cumulative viewshed (left), and b) the reflective cumulative viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

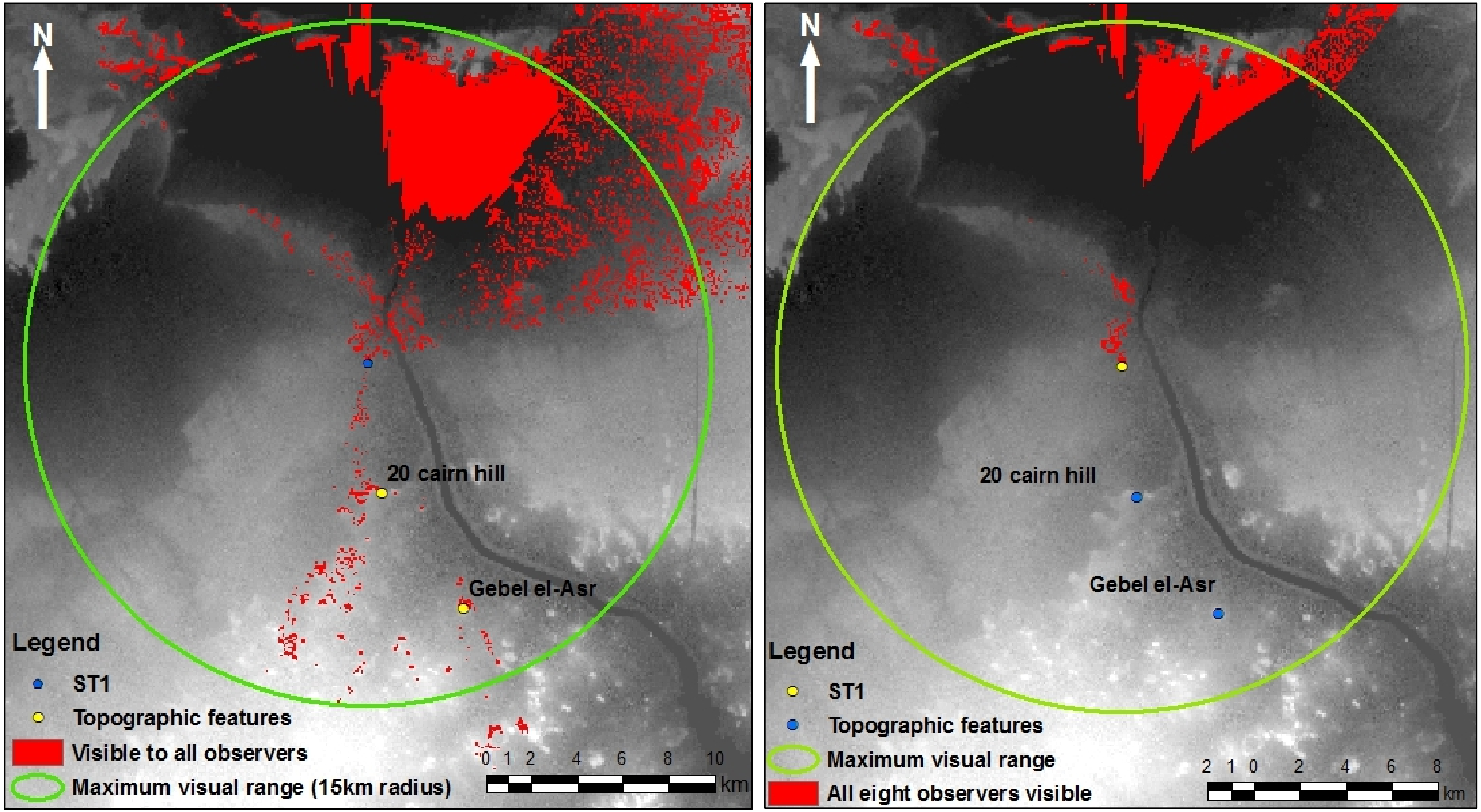


Fig 5.5: a) The projective cumulative viewshed visible to all eight courts (left), and b) the reflective cumulative viewshed where all eight courts would be visible (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data available from the USGS).

The reflective cumulative viewsheds are generally larger than the projective cumulative viewsheds indicating that the courts were quite visible to the surrounding landscape, but had more limited views of it. However, the cumulative viewsheds for all eight courts represent an exception (Fig 5.5). The area visible to all eight courts in the projective cumulative viewshed analysis was 82.45km^2 and represented 66.85% of the total visible area, while the area from which all eight courts could be seen in the reflective cumulative viewshed analysis was much smaller at only 27.36km^2 or 15.86% of the total visible area. This difference is also evident in the appearance of the viewsheds. The projective cumulative viewshed shows that areas to the north, north-east and south of Stelae Ridge was visible to all eight courts (Fig 5.5a), but only a small area to the north of Stelae Ridge had a view of all eight courts in the reflective cumulative viewshed (Fig 5.5b). This suggests that visibility of all the courts simultaneously was not a priority for their builders and, in at least some cases, no particular effort was made to ensure the courts were visible.

In terms of local landforms, at least some areas of both 20 cairn hill and the Gebel el-Asr were visible to all eight courts, but only five courts were visible from them (Fig 5.2). Since five of the courts were located on the southern ridge, this suggested there was a significant difference in visibility between the five courts on the southern ridge and the three on the northern ridge, which was later revealed in more detail in the observer points analysis

5.1.2. Observer points analysis of the courts

The observer points analysis determined exactly which areas of the landscape could be seen from each observer point in each court or from where each observer point could be seen. This produced a very complex image from which viewsheds for individual courts or groups of courts were extracted.

Exclusive viewsheds of each court

To assess whether any one court had a very different viewshed compared to the others, the areas that were exclusively visible to each court or had exclusive visibility of each court were extracted from the observer points analysis.[247] The viewsheds are shown in Fig 5.6 and Table 5.2.

[247] For ‘exclusive’ visibility see Chapter 2 section 2.4.3.

Table 5.2: Areas of exclusive projective and reflective viewsheds for each observer point in each court.

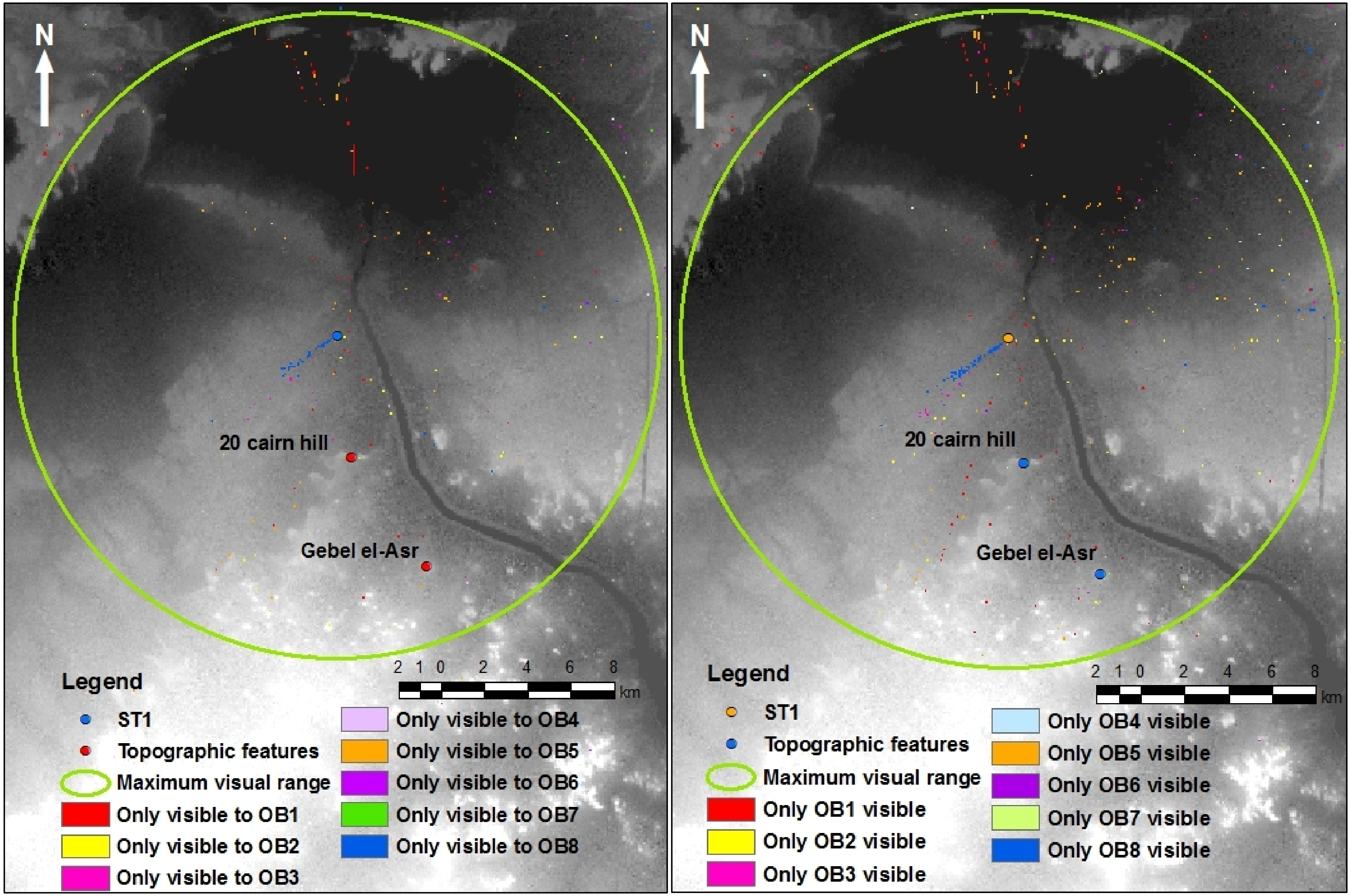
Observer point	Court	Projective			Reflective		
		Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
		Number	Area (km^2)		Number	Area (km^2)	
OB1	I	93	0.70	0.56	106	0.79	0.46
OB2	II	26	0.19	0.16	48	0.36	0.21
OB3	III	25	0.19	0.15	51	0.38	0.22
OB4	IV	16	0.12	0.10	34	0.25	0.15
OB5	V	69	0.52	0.42	114	0.85	0.49
OB6	VI	16	0.12	0.10	7	0.05	0.03
OB7	VII	10	0.07	0.06	1	0.01	<0.00
OB8	VIII	49	0.37	0.30	81	0.61	0.35
Total	**All**	**304**	**2.27**	**1.84**	**442**	**3.3**	**1.91**

The exclusive reflective viewsheds for each court are generally larger than the equivalent exclusive projective viewshed, but both are small, compared to the total visible area, and diffuse in location. No one court exhibits an unusually sized or significantly located viewshed.

To the south-west of Stelae Ridge, there are several south-west to north-east alignments of raster cells, which were visible from a single court or had exclusive visibility of a court. These may reflect genuine facets of the visibility of these courts, but are more likely to be a product of the azimuths.[248] They do not relate to any topographic or archaeological features of particular significance.

Next page, Fig 5.6: a) Areas only visible to one court (left) and b) areas where only one court was visible (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data available from the USGS).

[248] The effect of the azimuths will be considered further in section 5.2.


N
20 cairn hill
Gebel el-Asr
2 1 0 2 4 6 8
km
Legend
ST1
Topographic features
Maximum visual range
Only visible to OB1
Only visible to OB2
Only visible to OB3
Only visible to OB4
Only visible to OB5
Only visible to OB6
Only visible to OB7
Only visible to OB8
N
20 cairn hill
Gebel el-Asr
2 1 0 2 4 6 8
km
Legend
ST1
Topographic features
Maximum visual range
Only OB1 visible
Only OB2 visible
Only OB3 visible
Only OB4 visible
Only OB5 visible
Only OB6 visible
Only OB7 visible
Only OB8 visible

Stelae Ridge North and Stelae Ridge South

The cumulative viewshed analysis suggested that the two different ridges may have different properties with regard to visibility, affecting the views from and visibility of the structures on them. To assess the effect of the different ridges upon the visibility of the structures, projective and reflective viewsheds were extracted from the observer points analysis showing the areas visible from and with views of all the courts on each ridge. Both inclusive and exclusive queries were constructed for each ridge.[249] The sizes of the inclusive and exclusive projective and reflective viewsheds for all the courts on each ridge are presented in Table 5.3. Fig 5.7 shows the projective viewsheds for both ridges and Fig 5.8 shows the reflective viewsheds for both ridges.

Table 5.3: Sizes of the viewsheds for all the courts on each ridge, by ridge.

	Projective			Reflective		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
Ridge	Number	Area (km^2)		Number	Area (km^2)	
North Exclusive	5	0.04	0.03	6	0.04	0.03
North Inclusive	11290	84.4	68.44	3679	27.50	15.94
South Exclusive	638	4.77	3.87	7085	52.96	30.70
South Inclusive	14790	110.56	89.65	20768	155.25	89.98

There are considerable differences between the ridges. In both the projective and reflective viewsheds, the viewsheds for Stelae Ridge south are much larger than those for Stelae Ridge north and occupy a much greater radius around the site. The five courts on Stelae Ridge south have a good view of the surrounding landscape and are highly visible within it; their individual viewsheds must be large and are probably quite consistent with each other.

[249] This should not be taken to imply that all the courts on a given ridge are similar in form, date or specific function. As discussed in Chapter 3 section 3.2, the archaeological evidence indicates that courts on the same ridge may be quite different and courts on different ridges may contain similar artefacts or structures, or may date to the same reign.

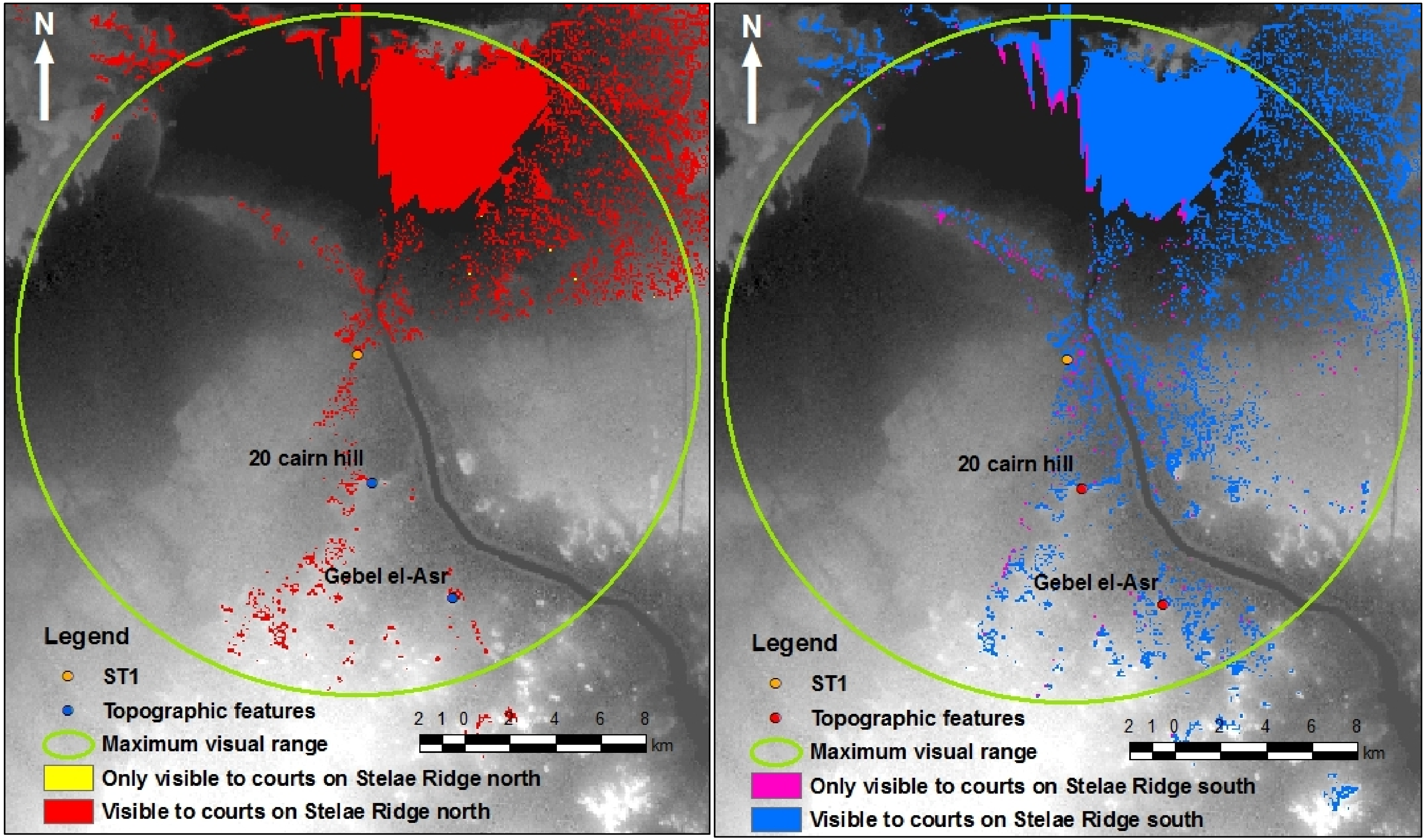


Fig 5.7: a) Inclusive (red and yellow) and exclusive (yellow only) projective viewshed for Stelae Ridge north (left), and b) inclusive (blue and pink) and exclusive (pink only) projective viewshed for Stelae Ridge south (right). Note that the exclusive viewshed for Stelae Ridge south is so small it is almost invisible. Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

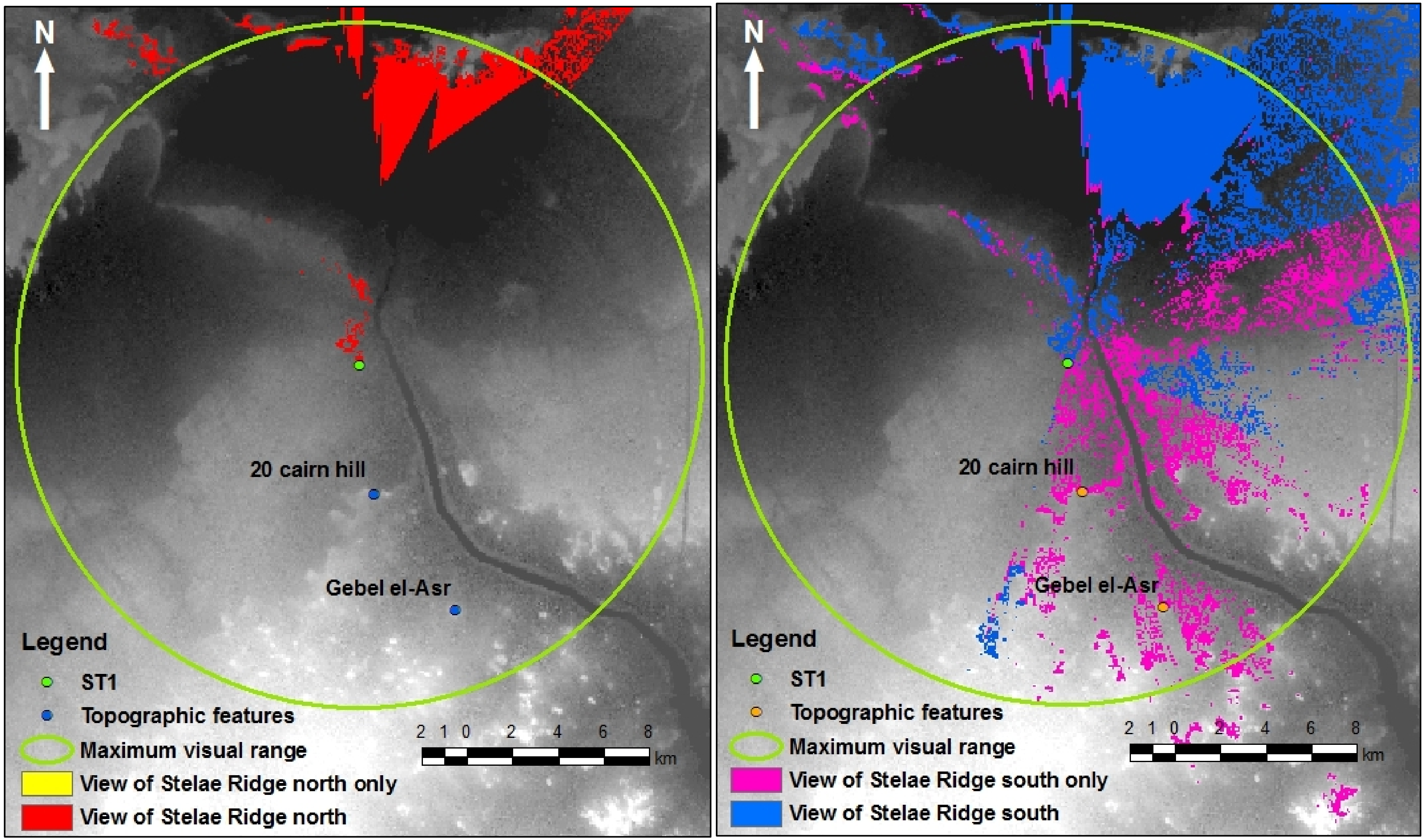


Fig 5.8: a) Inclusive (red and yellow) and exclusive (yellow only) reflective viewshed for Stelae Ridge north (left), and b) inclusive (blue and pink) and exclusive (pink only) reflective viewshed for Stelae Ridge south (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

There is a notable difference between the projective and reflective inclusive viewsheds for Stelae Ridge north. Although the reflective visibility analysis generally produces larger viewsheds, the 27.50km^2 reflective viewshed for Stelae Ridge north is much smaller than the equivalent 84.40km^2 projective viewshed. The inclusive viewsheds for Stelae Ridge north closely resemble the cumulative viewshed for all eight courts in size and appearance (Table 5.1 and Fig 5.5). This suggests that the cumulative viewsheds for all eight courts are primarily limited by the viewsheds of one or more courts on Stelae Ridge north, although the inclusive viewsheds for Stelae Ridge north are slightly larger than the cumulative viewsheds for all eight courts.[250]

The areas exclusively visible to Stelae Ridge north are virtually non-existent at 0.03–0.04km^2. Almost all of the area visible to the courts on Stelae Ridge north is therefore also visible to those on Stelae Ridge south, emphasising the more limited views from and visibility of Stelae Ridge north.

The large exclusive reflective viewshed for Stelae Ridge south is a result of the very small area from which Stelae Ridge north is visible. Stelae Ridge south had a better view of more of the landscape than Stelae Ridge north in the projective visibility analysis, but the reflective visibility analysis shows it was also *much* more visible to observers in that landscape, including substantial areas that had no view of Stelae Ridge north.

Overall, the viewsheds for all the courts on each ridge revealed that there are significant differences between the projective and reflective viewsheds of the Stelae Ridge north courts and between the viewsheds of the courts on the two different ridges. The implications of this are significant for interpretation of the structures at the site. While the Stelae Ridge south courts have better views than those on Stelae Ridge north, they are also *very* much more visible than the northern courts. This suggests that Stelae Ridge south is a far better location for structures that must be visible, a conclusion that is confirmed by the visibility analysis of the cairns, which are by nature much more visible than the courts.[251]

Viewsheds of individual courts

Variation amongst the viewsheds of the individual courts has significant implications for the interpretation of the site, including its chronological development. It provides confirmation of suggestions made in the previous sections concerning the influence of the courts on Stelae

---

[250] The slight differences in size reflect areas visible to the courts on Stelae Ridge north, but not visible to other courts that contributed to the projective cumulative viewshed for all eight courts.
[251] For the visibility analysis of the cairns see section 5.3.

Ridge north upon the cumulative viewsheds for all eight courts,[252] the consistency of the viewsheds of the courts on Stelae Ridge south and the significant differences between the courts on Stelae Ridge south and Stelae Ridge north, particularly in the reflective visibility analysis.

The inclusive projective and reflective viewsheds showing, respectively, the areas visible to each court and where each court could be seen from were extracted from the observer points analysis (Fig 5.9 – Fig 5.16). The sizes of the viewsheds shown in these figures are given in Table 5.4. It should be noted that all of these are inclusive queries. The exclusive queries for each observer point are shown in Fig 5.6 and discussed above.

Table 5.4: Area of inclusive projective and reflective viewsheds for each observer point.

Observer point	Court	Projective			Reflective		
		Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
		Number	Area (km^2)		Number	Area (km^2)	
OB1	I	15630	116.84	94.74	21794	162.92	94.42
OB2	II	15649	116.98	94.85	21960	164.16	95.14
OB3	III	15935	119.12	96.59	22337	166.98	96.78
OB4	IV	15409	115.19	93.40	21691	162.15	93.98
OB5	V	15663	117.09	94.94	21949	164.08	95.10
OB6	VI	14703	109.91	89.12	8574	64.09	37.15
OB7	VII	11499	85.96	69.70	4811	35.96	20.84
OB8	VIII	13696	102.38	83.02	12354	92.35	53.52
TVA	Any	16498	123.33	100.00	23081	172.54	100

The projective and reflective viewsheds are not reciprocal, but they have a number of features in common, most notably OB3 had the largest viewshed (Fig 5.11) and court VII had the smallest viewshed (Fig 5.15) in both projective and reflective observer points analysis.

---

[252] It should be noted that OB1, OB3 and OB5 were not located in dry-stone courts (Chapter 2, section 2.5.1). OB1 and OB5 were located east of the flat faces of cairns I and V, in what have been described as 'pseudo-courts'. As these areas probably fulfilled the same purpose as the courts at other cairns they are described as 'court I' and 'court V', except where it is necessary to differentiate them from the dry-stone courts. For consistency and to ensure it could be compared with the other courts, OB3 was located to the east of cairn III even though this area probably did not function as a court in the same way as the other courts or pseudo-courts (Chapter 3, section 3.2.4). Where possible OB3 is referred to as such, but it should be noted that 'court III' has been used where necessary and refers to what would have been visible from a court around OB3, if such a structure had existed.

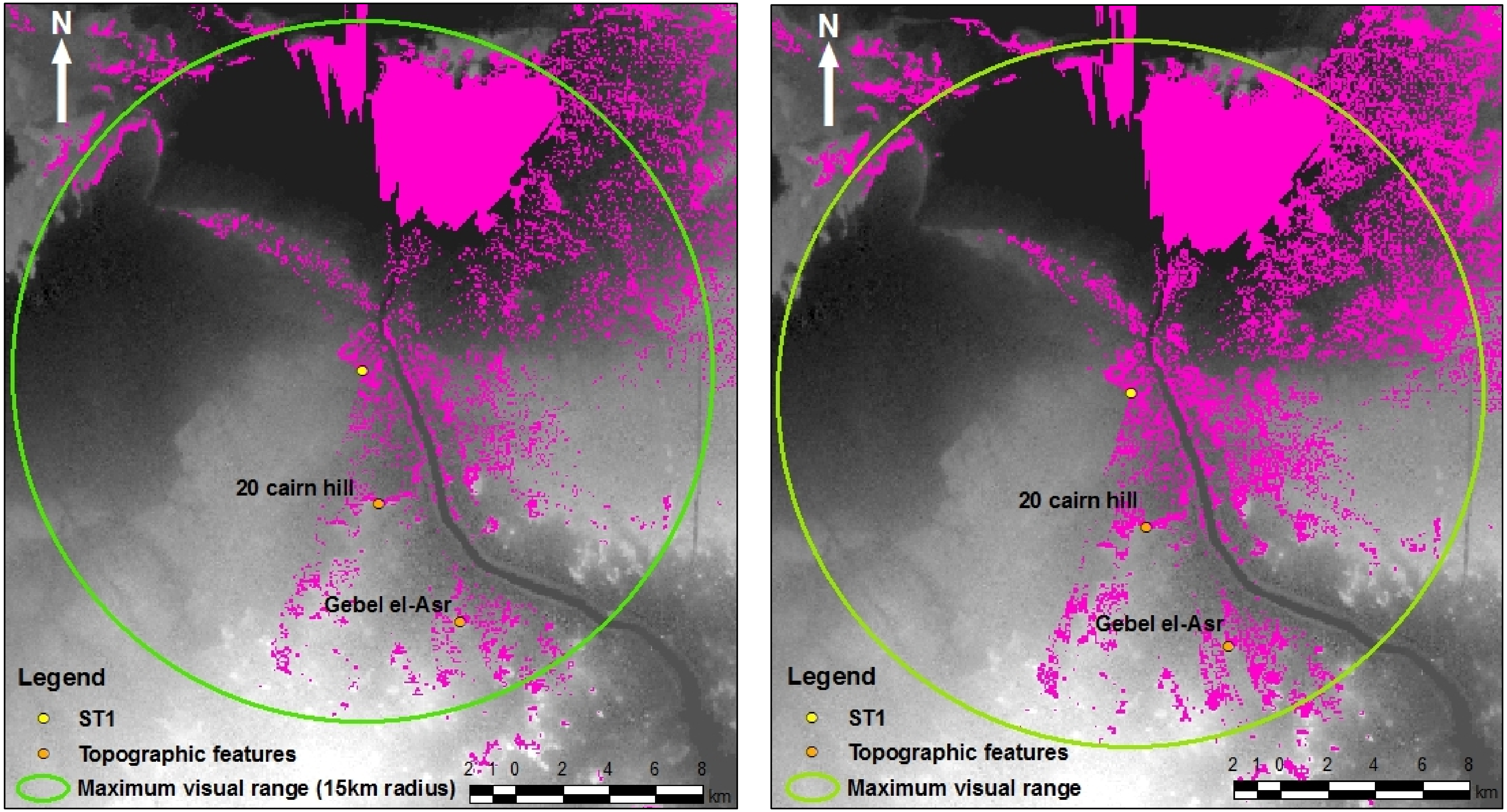


Fig 5.9: Individual inclusive viewsheds for court I, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

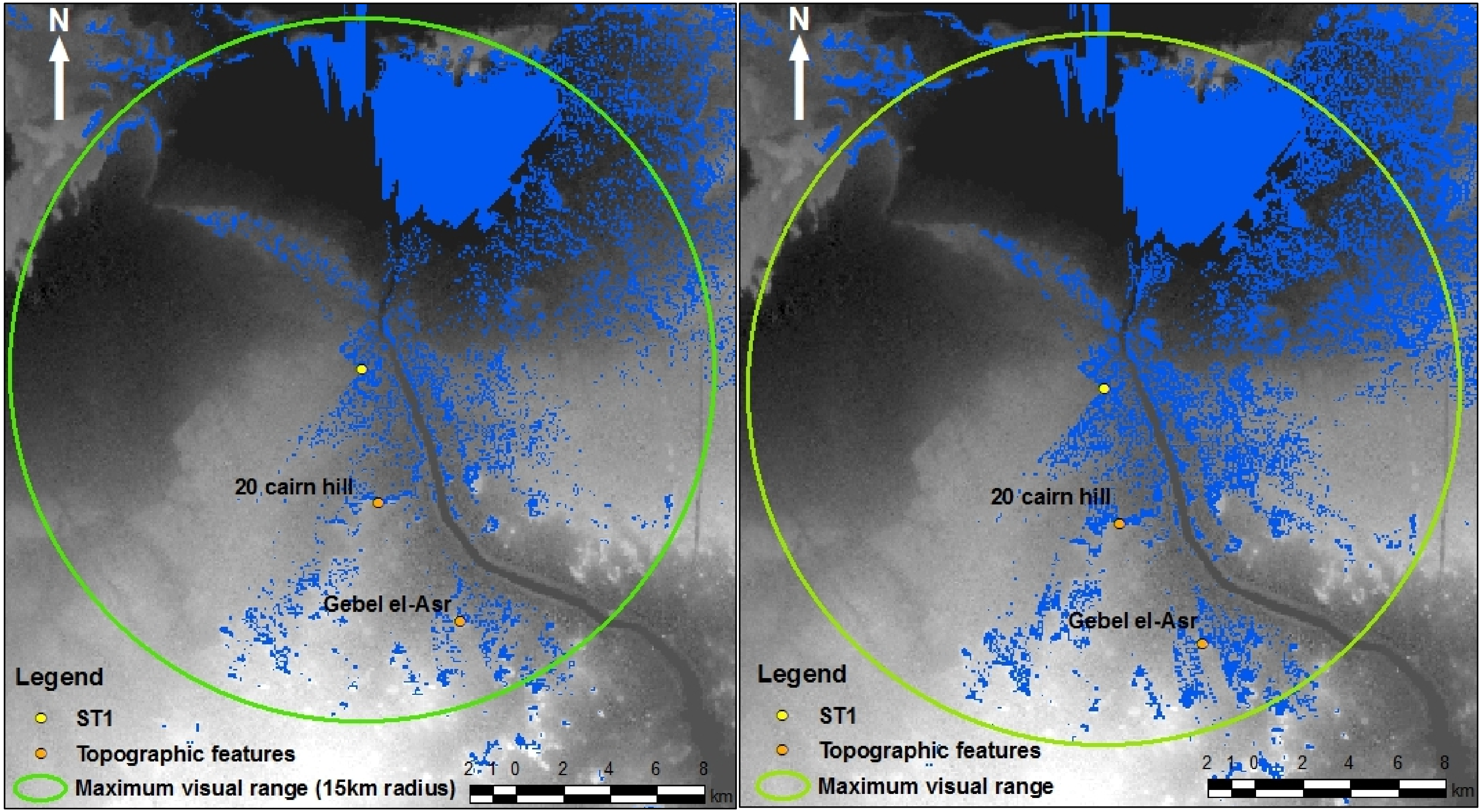


Fig 5.10: Individual inclusive viewsheds for court II, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

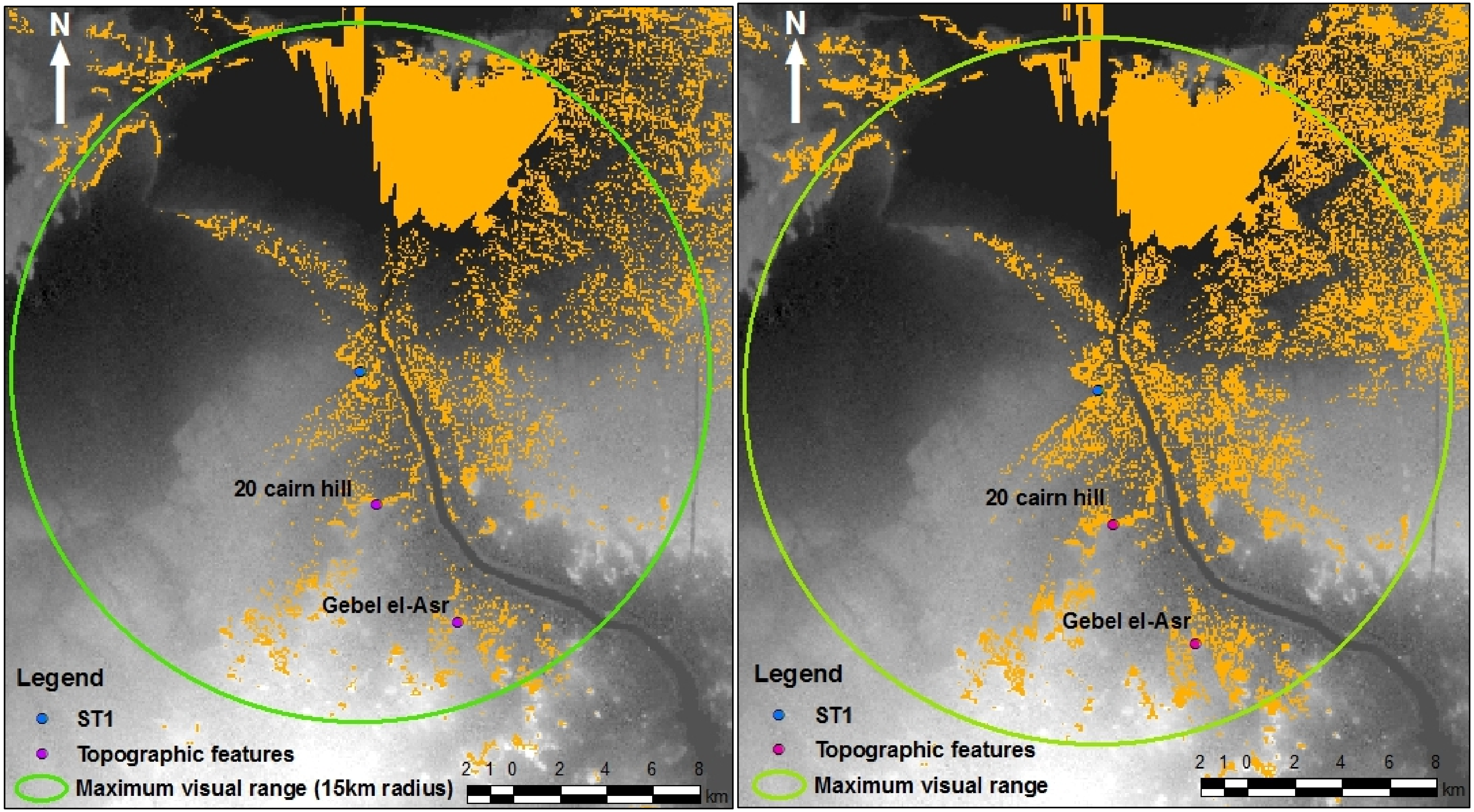


Fig 5.11: Individual inclusive viewsheds for OB3, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

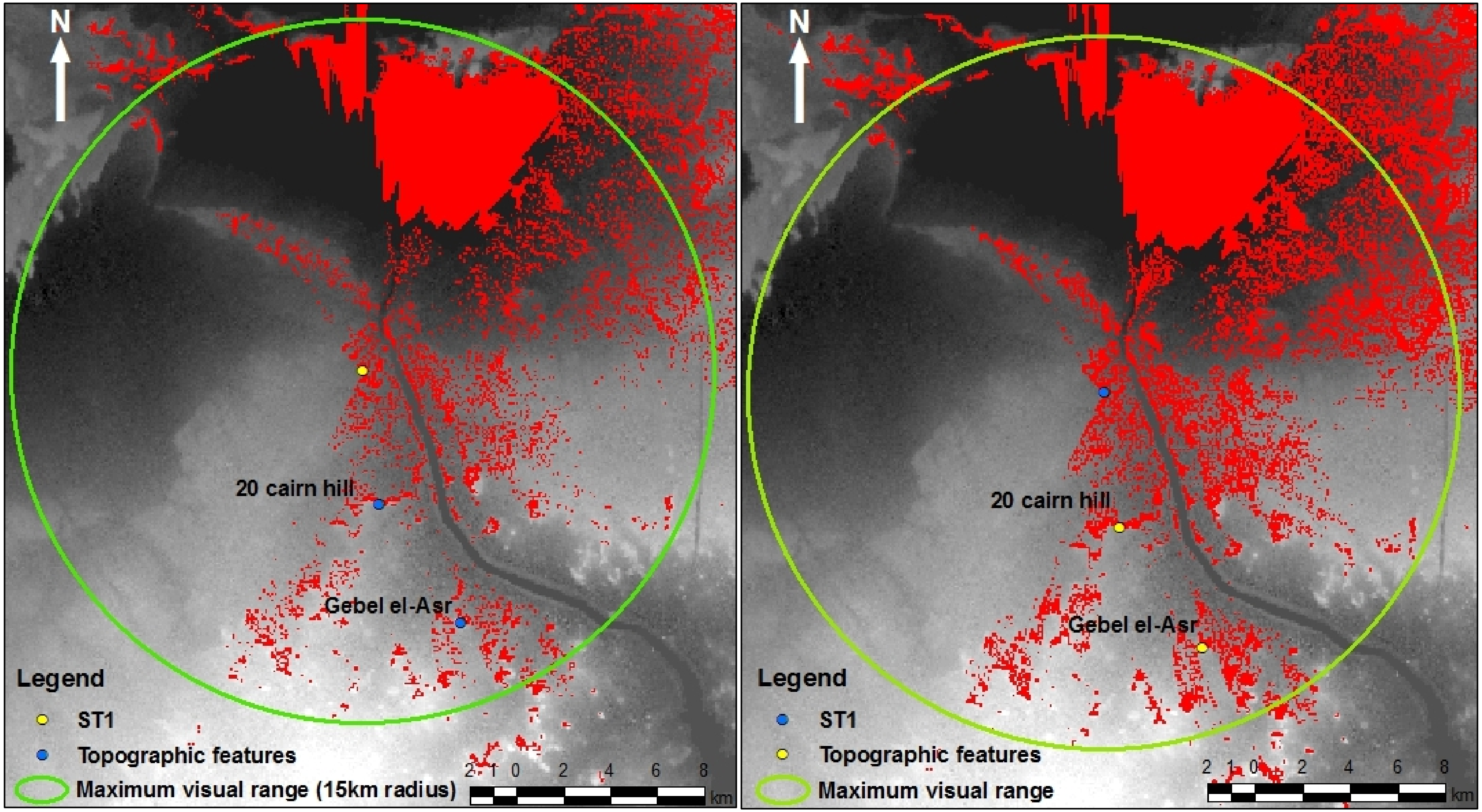


Fig 5.12: Individual inclusive viewsheds for court IV, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

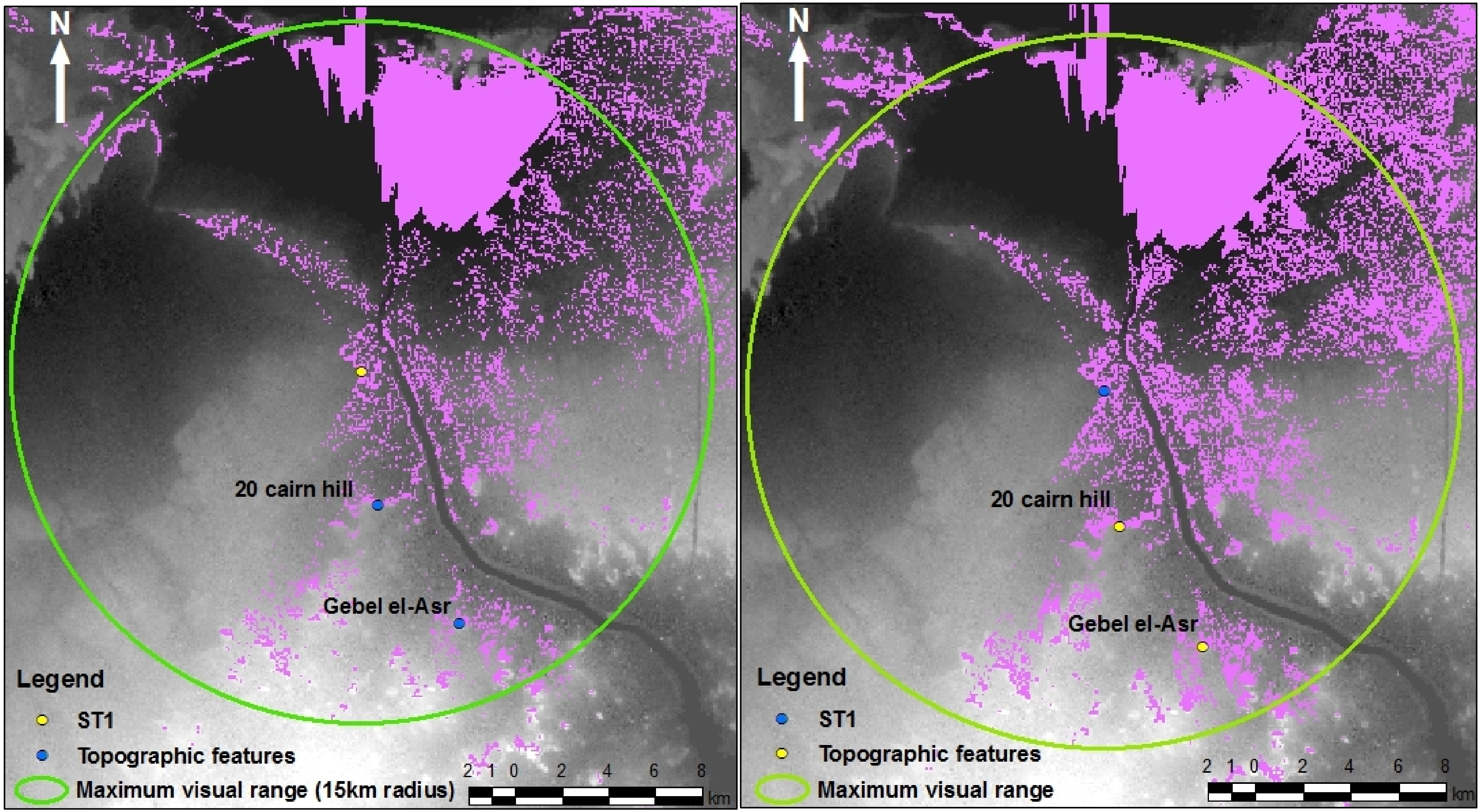


Fig 5.13: Individual inclusive viewsheds for court V, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

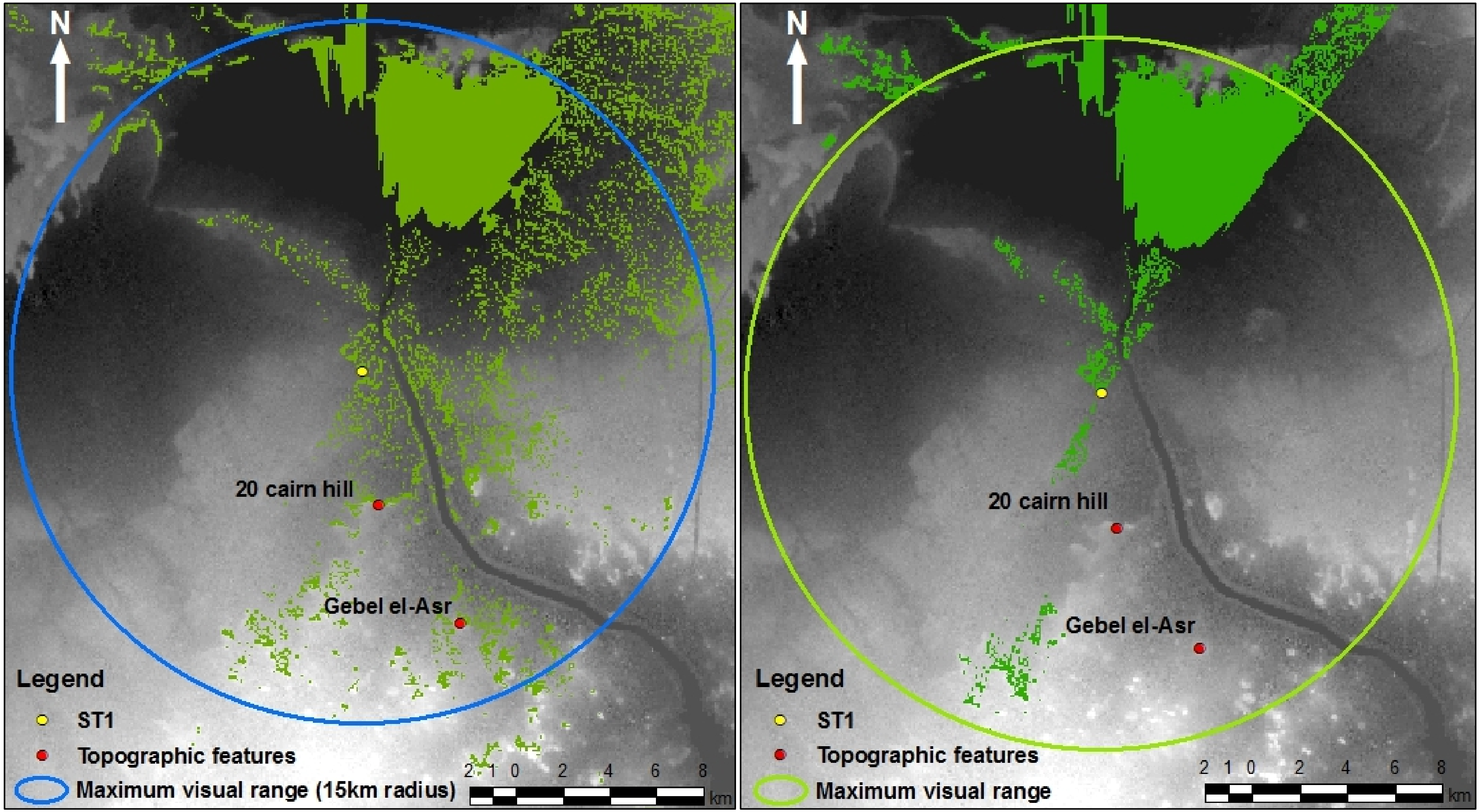


Fig 5.14: Individual inclusive viewsheds for court VI, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

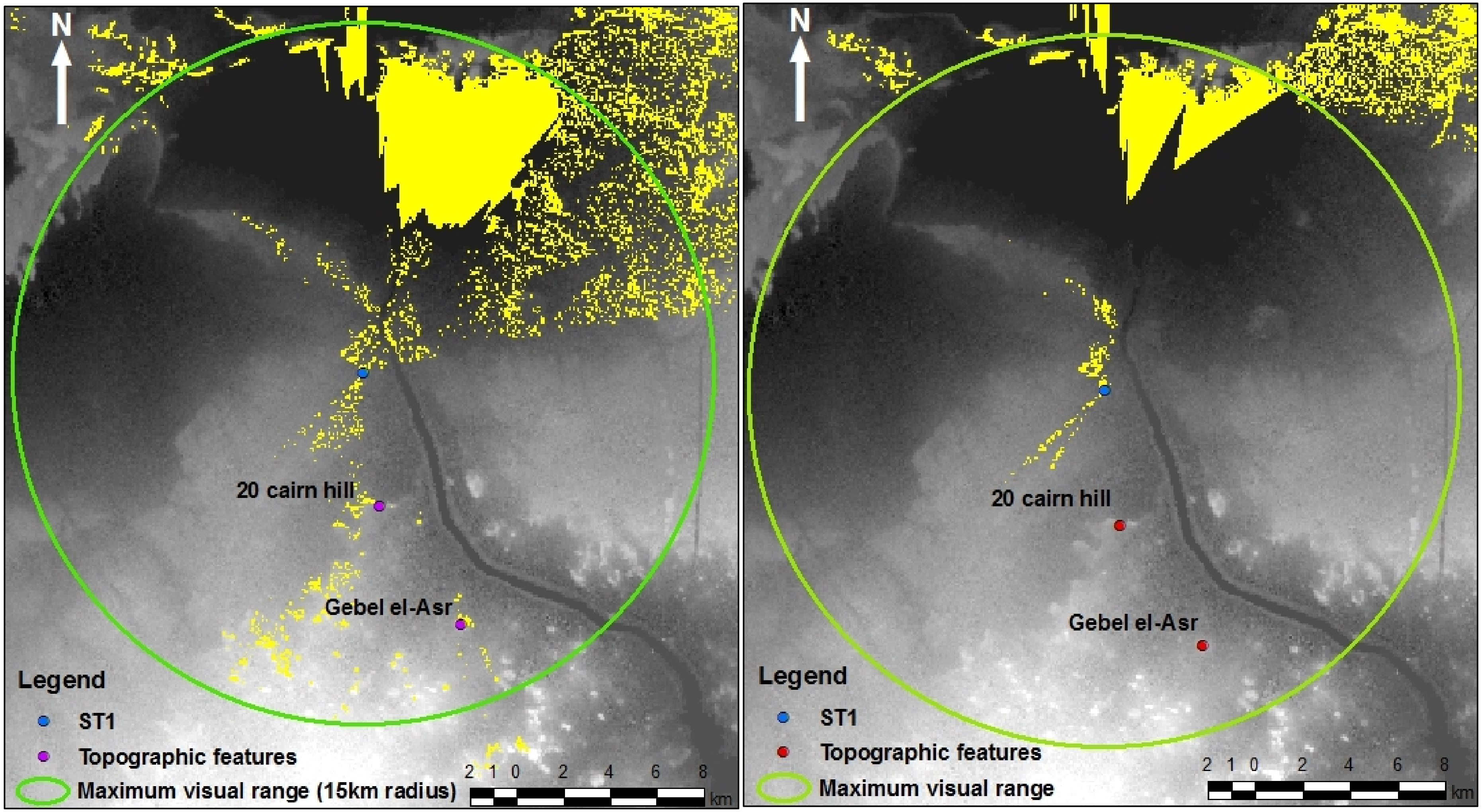


Fig 5.15: Individual inclusive viewsheds for court VII, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

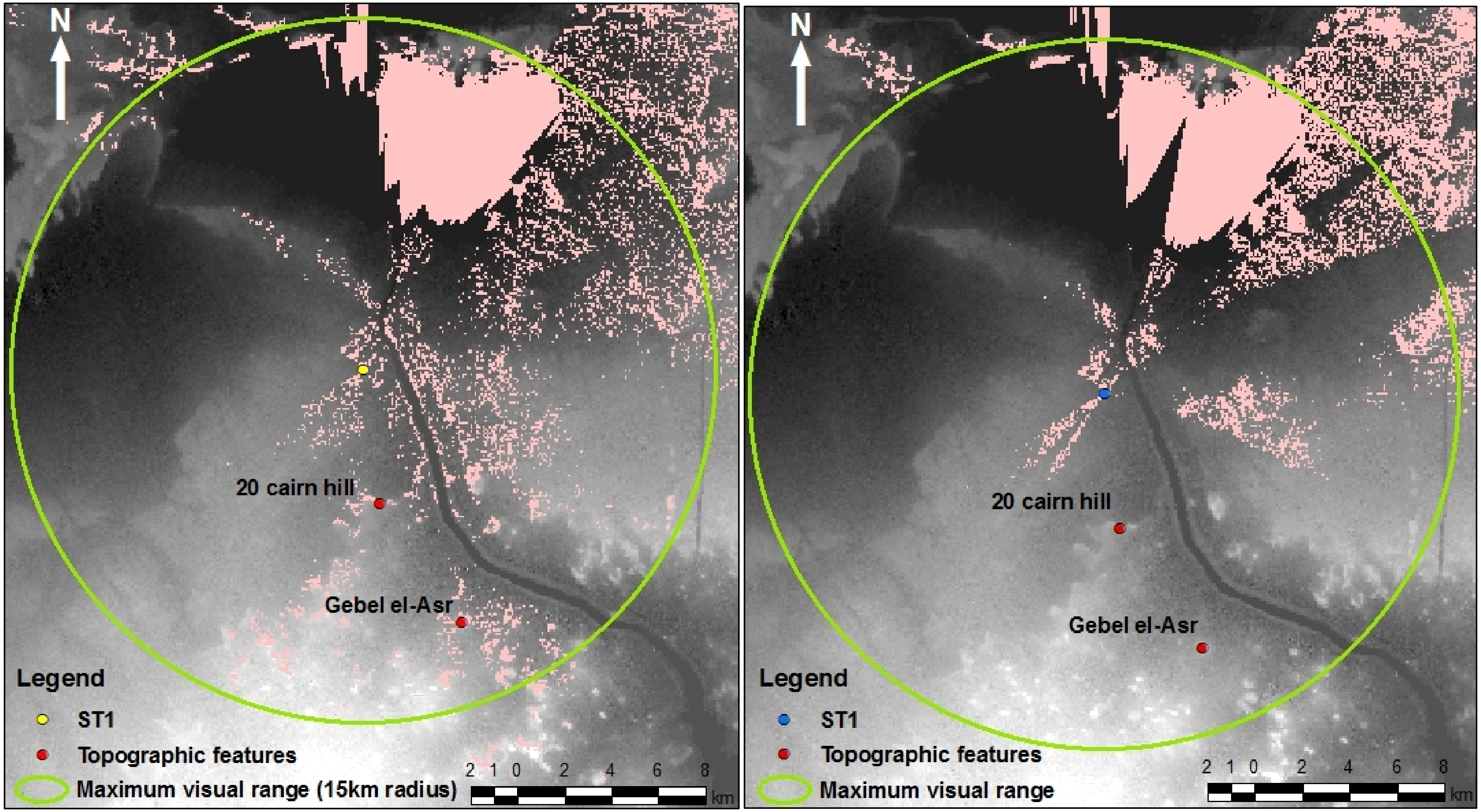


Fig 5.16: Individual inclusive viewsheds for court VIII, a) projective viewshed (left), and b) reflective viewshed (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

The viewsheds of each court confirm many of the conclusions drawn in previous sections, particularly with regard to the differences between Stelae Ridge south and Stelae Ridge north. Courts I-V on the southern ridge had the largest projective and reflective viewsheds, which were quite consistent with each other, in terms of both size and appearance. The projective and reflective viewsheds of courts VI-VIII on the northern ridge were generally smaller and included the smallest of all the viewsheds.

There are also notable differences between the projective and reflective viewsheds of the courts on each ridge. Courts I-V on Stelae Ridge south have very much larger reflective than projective viewsheds, while the reflective viewsheds of courts VI–VIII on the northern ridge are smaller than their equivalent projective viewsheds.

The viewsheds of courts VI-VIII on Stelae Ridge north were also much more variable than those of courts I-V. The projective viewsheds of both court VI and, to a lesser extent, court VIII exhibited similarities with the projective viewsheds of courts I-V, but the projective viewshed of court VII was quite different in terms of its size and the areas visible from it (Fig 5.15). Visually and numerically, the projective viewshed of court VII was very similar to the projective cumulative viewsheds of all eight courts (Table 5.1 and Fig 5.5) and of all the courts on the northern ridge (Table 5.3 and Fig 5.7a). Court VII's viewshed largely determined the size and shape of the projective viewshed of all courts on the northern ridge and the projective cumulative viewshed of all eight courts. There was even more variation between the reflective viewsheds of courts VI-VIII than their projective viewsheds.

Overall, courts I-V on Stelae Ridge south were found to have large and consistent projective and reflective viewsheds. The viewsheds of courts VI-VIII on Stelae Ridge north were smaller than those on the southern ridge, very much smaller in the case of the reflective viewsheds, and they also exhibited more intra-ridge variability in size and consistency. These differences confirm that courts I-V had better views of the landscape and were much more visible from it than courts VI-VIII on Stelae Ridge north. While all the courts except for court VII had a view of 20 cairn hill and the Gebel el-Asr, the reflective viewsheds revealed that only courts I-V were visible from these topographic features.

It is unlikely that the small variations in viewshed size between courts I-V on Stelae Ridge south would have been clear to a subjective observer assessing visibility from personal experience alone, without GIS analysis. When present at Stelae Ridge south the author experienced a sensation of good visibility from the entire ridge, but would not have been able to differentiate subtle variations in visibility at different locations on it. Although the differences in visibility may not have been directly perceptible to the courts' builders, there may be an association between the position of the court on the ridge and the size of its viewshed, with courts on the central crest being better situated and having larger viewsheds. Thus the differences between the viewsheds of courts I-V may reflect decisions about the topographic positioning of the structures, which in turn affected their visibilities.

The general difference in visibility between the northern and southern ridges and differences between the visibilities of the courts on Stelae Ridge north would probably have been perceptible to ancient human subjects, because they are more substantial than the differences between the courts on the southern ridge. During fieldwork on the site in 2012 the author observed a general decline in visibility on Stelae Ridge north. There was a general impression that court VI had a better view, particularly to the south, court VIII had a good view of the area to the north, and court VII had the most limited view, although this naturally depends on the specific environmental conditions on any particular day.[253] The positioning of the structures on Stelae Ridge north may therefore have been influenced by visibility from them, or, like the structures on Stelae Ridge south, the differences in visibility may reflect choices made on the basis of the topography of the ridge.

Viewsheds for all courts with the same artefacts

It is possible to query the observer points analysis and extract viewsheds for groups of courts based upon the type of artefacts within them, the type of structures they included, and the reign during which they were constructed.[254]

Projective and reflective viewsheds were extracted showing the areas visible to and with views of all the courts which produced the following types of artefacts:

a. Courts with stelae (Court I, II, IV, V, VI, VII and VIII)
b. Courts with offering tables (Court VII and VIII)
c. Courts with falcon figures (Court I, VI and VII).

Fig 5.17 shows the inclusive projective viewsheds for groups based on the types of artefacts found. Fig 5.18 shows the inclusive reflective viewsheds. The sizes of the viewsheds are detailed in Table 5.5.

---

[253] For the practical effects of haziness upon visibility see the differences between the panorama in Chapter 3, section 3.7.3 (Fig 3.26 and Fig 3.27).
[254] The artefacts, dates and layout of the courts are discussed in Chapter 3, section 3.2. The very limited records and artefacts kept by the original excavators make it difficult to be sure groups of courts are complete. It is therefore impossible to be certain if the categories are exhaustive, but they are the best that can be achieved with the available information.

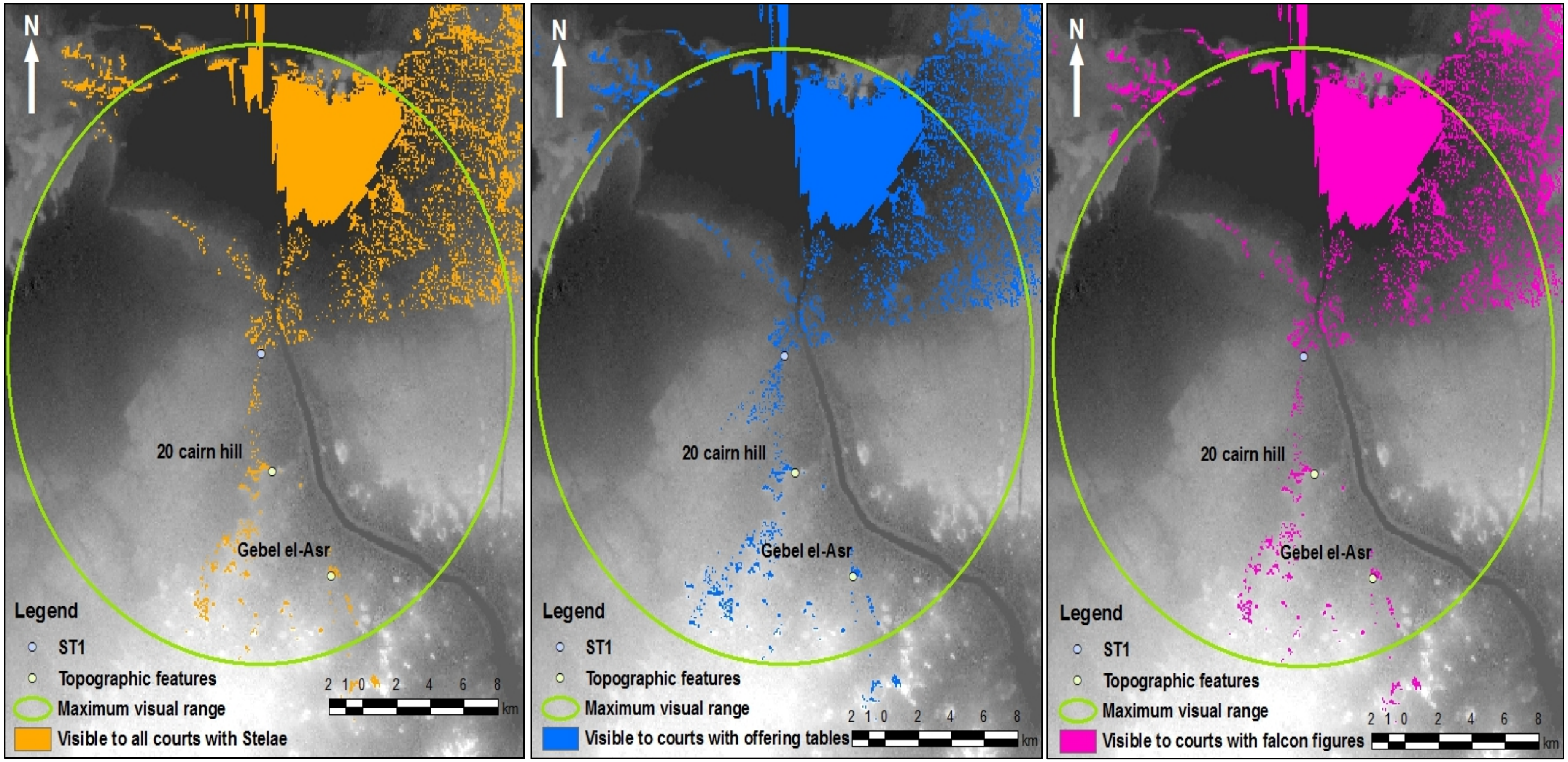


Fig 5.17: Comparison of the projective viewsheds visible from all the courts associated with a) stelae (left); b) offering tables (middle); c) falcons (right). The viewsheds are virtually identical because the groups all include court VII. Viewsheds and vector data are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

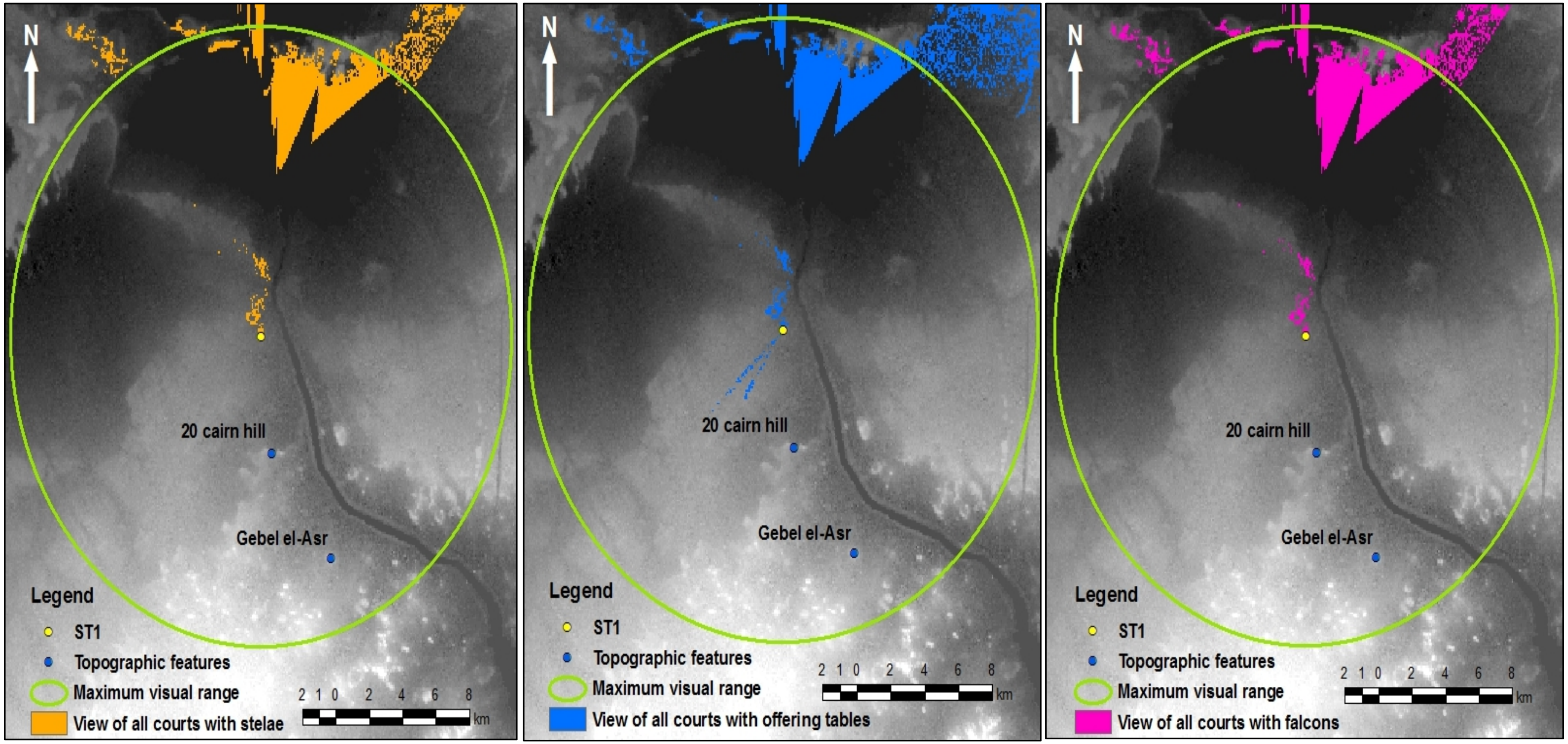


Fig 5.18: Comparison of the reflective viewsheds where all the courts with a) stelae (left); b) offering tables (middle); and c) falcons (right) are visible. The viewsheds are virtually identical because the groups all include court VII. Viewsheds and vector data are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

Table 5.5: Areas of projective and reflective viewsheds visible to groups of courts associated with specific types of artefacts.

	Projective			Reflective		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
Courts with . .	**Number**	**Area (km^2)**		**Number**	**Area (km^2)**	
Stelae	11036	82.50	66.89	3661	27.37	15.86
Offering tables	11405	85.26	69.13	4758	35.57	20.61
Falcon figures	11157	83.40	67.63	3707	27.71	16.06
Any (TVA)	16498	123.33	100	23081	172.54	100

The projective viewsheds for courts with stelae, offering tables and falcon figures are very similar in both appearance and size. There is slightly more variation in the reflective viewsheds (Fig 5.18), which are also substantially smaller than the projective viewsheds.

However, these similarities are not meaningful because all these groups include court VII, which has the smallest projective and reflective viewsheds. Since the viewshed for the entire group cannot be any larger than the smallest individual viewshed of a court within that group, the viewshed of court VII will determine the size and shape of the viewshed of any group that includes it.

A review of the individual viewsheds for all the courts included in each of the groups (Fig 5.9–Fig 5.16) indicates that there is considerable intra-group variability. Therefore it must be concluded that there is no consistent relationship between courts containing particular artefacts and viewshed size or shape.

Viewsheds for all courts with the same structure

The projective and reflective viewsheds associated with different types of court structure were also extracted from the observer points analysis:

a. Courts, set against the flat eastern side of the cairn and outlined in stone to some extent (Court II, V, VI, VII and VIII).
b. Pseudo-courts that were not outlined in stones, but where the eastern side of the cairn was flat (Court I and IV).
c. Non-courts where the cairn was round and there was neither a flat side, nor a discernible court (OB3 at cairn III).

Fig 5.19 shows the inclusive projective viewsheds for all the courts in each of the groups and Fig 5.20 shows the inclusive reflective viewsheds. The sizes of the viewsheds are detailed in Table 5.6.

Table 5.6: Areas of projective and reflective viewsheds visible to all the courts in each group.

Type of court	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)		Number	Area (km^2)	
Court	11236	83.99	68.11	3673	27.46	15.91
Pseudo-court	14992	112.07	90.87	21079	157.57	91.33
No court	15935	119.12	96.59	22337	166.98	96.78
TVA	16498	123.33	100	23081	172.54	100

The projective and reflective viewsheds associated with OB3, the observer point without a court, and the pseudo-courts are very similar. They have large reflective and projective viewsheds, representing a high proportion of the total visible area. The viewsheds associated with the group with court structures are much smaller, particularly the reflective viewshed.

The small viewsheds of the group with courts is due to the presence of courts on the northern ridge in that group. As with the groups based on artefact type, the small individual viewsheds of the courts on the northern ridge, particularly court VII, limit the size of the viewshed of the entire group, even though that group includes courts on the southern ridge that have much larger individual viewsheds. Since court structures are associated with very variably-sized individual viewsheds (Table 5.4 and Fig 5.9–Fig 5.16), there is no consistent relationship between court structures and visibility.

The larger viewsheds of the pseudo-courts and OB3 reflects their position on the southern ridge, which is generally associated with larger viewsheds and an increase in viewshed size from the projective to the reflective viewshed. It is difficult to determine if there is any significant relationship between the larger viewsheds and either the pseudo-courts or the absence of a court at cairn III, but the consistency between them means that it is possible that a larger viewshed was deliberately sought for some or all of these structures.

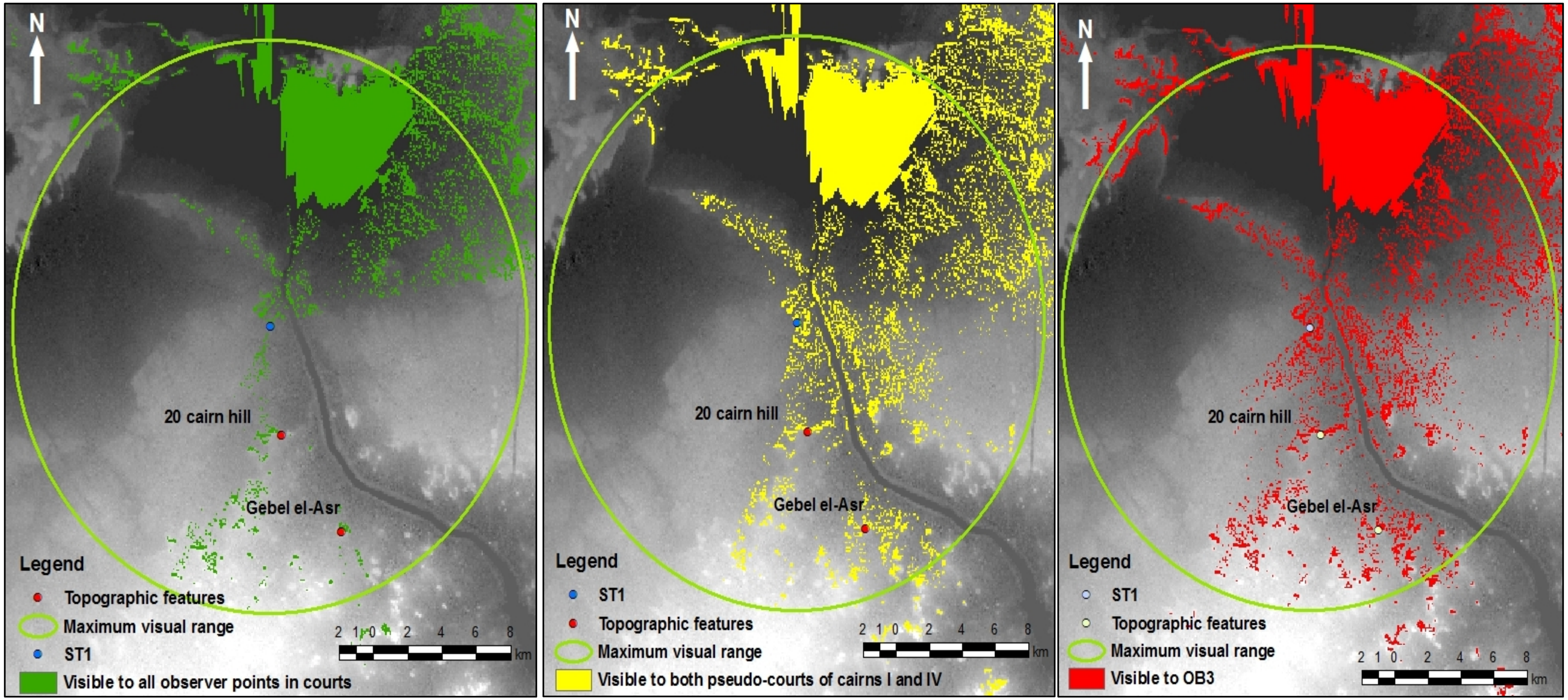


Fig 5.19: Comparison of the projective viewsheds associated with a) courts (left); b) pseudo-courts, where the cairns have flat eastern sides but the 'court' is not outlined in stones (middle); c) the round cairn, cairn III (right). The viewsheds for pseudo-courts (middle) and cairn III (right) are much larger than the viewshed for the courts (left) because they are all on the southern ridge. Viewsheds and vector data are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

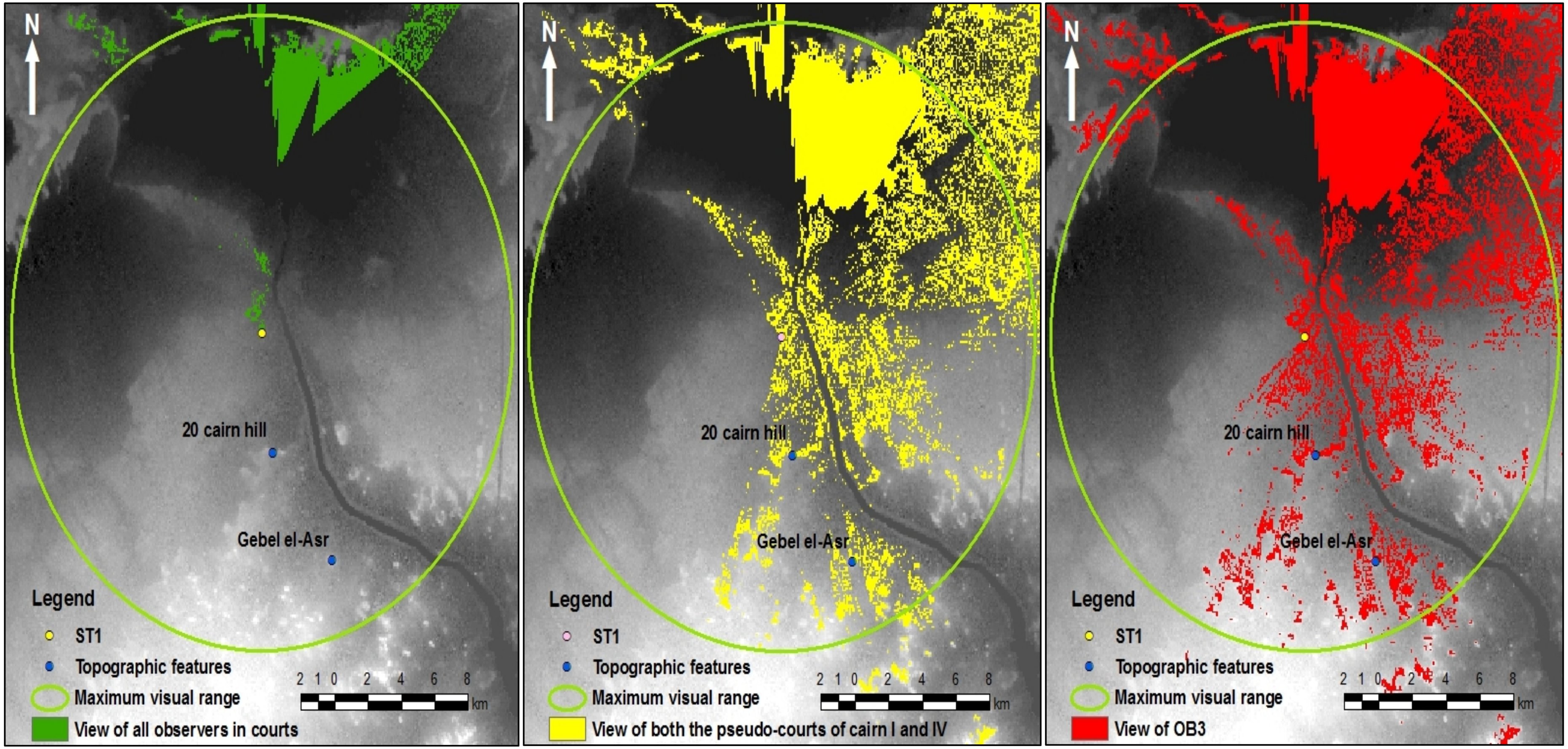


Fig 5.20: Comparison of the reflective viewsheds for groups with a) courts (left); b) pseudo-courts (middle); c) the round cairn with no court (right). Viewsheds and vector data are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

The larger viewsheds exhibited by cairn III and the pseudo-courts could be associated with an early date. It has been suggested that cairn III is an early structure, and pseudo-court IV is associated with the earliest dated material at Stelae Ridge.[255] However, pseudo-court I contained material dating to Amenemhat III, the latest attested Pharaoh at Stelae Ridge. It is possible that cairn I was an early cairn that was re-used or a later cairn whose court was removed. Otherwise the larger viewsheds of the pseudo-courts cannot be associated with an early date and the only factor common to both is their presence on the southern ridge, a feature they share with cairn III.

Viewsheds for all courts of the same reign

A key aim of this project is to assess how far the visual characteristics of a site like Stelae Ridge can be used to interpret the remains found there. Although the pottery at the site was almost entirely Middle Kingdom,[256] this covers a large span of time and cannot assist in determining the order in which the structures were constructed. Only five of the eight structures at Stelae Ridge were associated with artefacts that recorded the reign and, in some cases, regnal year of a Pharaoh. The absence of dating evidence from the other structures was due to the poor preservation of the inscribed material rather than an absence of inscribed artefacts; except at cairn III, which was not associated with any artefacts.

The dated artefacts found within them divide the courts into two groups, those constructed prior to the reign of Amenemhat III and those constructed during it. Three courts (I, VII and VIII) date to the reign of Amenemhat III. Two courts date to earlier reigns: Court IV is associated with the co-regency of Amenemhat I and Senusret I and also had a stela of Senusret I, indicating that it is early 12th Dynasty. Court VI was associated with Senusret II, so is also earlier than the courts dated to Amenemhat III.[257]

The projective and reflective viewsheds of both courts pre-dating the reign of Amenemhat III and of all the courts in the group dating to his reign were extracted from the observer points analysis. Fig 5.21 shows the inclusive projective viewsheds for all the courts dating to the reign of Amenemhat III and all the courts pre-dating his reign. Fig 5.22 shows the inclusive reflective viewsheds for the same two groups. The viewsheds for court IV, dating to the co-regency of Amenemhat I and Senusret I are shown in Fig 5.12. The viewsheds for court VI,

---

[255] For the dated artefacts from the courts see Chapter 3, section 3.2.2–3.2.3. For the possible early date of cairn III see section 3.2.4 of the same chapter.
[256] One Old Kingdom and a few Roman pottery shards were found, but the rest of the material was Middle Kingdom (Shaw *et al.* 2003, 453).
[257] None of the other structures were associated with dated artefacts and courts II, III and IV could not be included in any of the groups. Darnell and Manassa (2006) believe court II may date to the reign of Amenemhat III, but the evidence for this attribution is unclear.

dating to the reign of Senusret II, are shown in Fig 5.14. The sizes of the viewsheds are given in Table 5.7.

Table 5.7: Areas of projective and reflective viewsheds, by reign.

Court	Reign	Projective: Raster cells: Number	Projective: Raster cells: Area (km^2)	Projective: Proportion of total visible area (%)	Reflective: Raster cells: Number	Reflective: Raster cells: Area (km^2)	Reflective: Proportion of total visible area (%)
IV	Amenemhat I and Senusret I	15409	115.19	93.40	21691	162.15	93.98
VI	Senusret II	14703	109.91	89.12	8574	64.09	37.15
IV and VI	Before Amenemhat III	14424	107.83	87.43	8420	62.94	36.48
I, VII and VIII	Amenemhat III	11158	83.41	67.63	4655	34.80	20.17

The absence of the other courts is not ideal, but they cannot be included because there is no evidence as to their date, other than that they are likely to be Middle Kingdom, specifically 12th Dynasty.

The projective and reflective viewsheds of the groups of courts dating to the reign of Amenemhat III are smaller than the viewsheds of the group that pre-dates Amenemhat III. The group dating to the reign of Amenemhat III has a projective viewshed similar to the cumulative viewshed for all eight courts (Fig 5.4) and the individual viewshed for court VII (Fig 5.15). As with the queries by artefact and court type, this reflects the impact of court VII upon the viewshed of any group that includes it. Both court I and court VIII also date to the reign of Amenemhat III and have much larger viewsheds than court VII (Table 5.4, Fig 5.9 and Fig 5.16), but these differences are not evident in the viewsheds for the group because court VII limits their size.

The variation amongst the viewsheds of the courts that are included in the group dating to the reign of Amenemhat III makes it highly improbable that the viewshed for the group can be associated with any deliberate or consistent choices. If either good or low visibility had been deliberately sought in the construction of courts dating to the reign of Amenemhat III, it is logical to conclude the entire group would have exhibited similarly good or poor visibility, but this was not so.

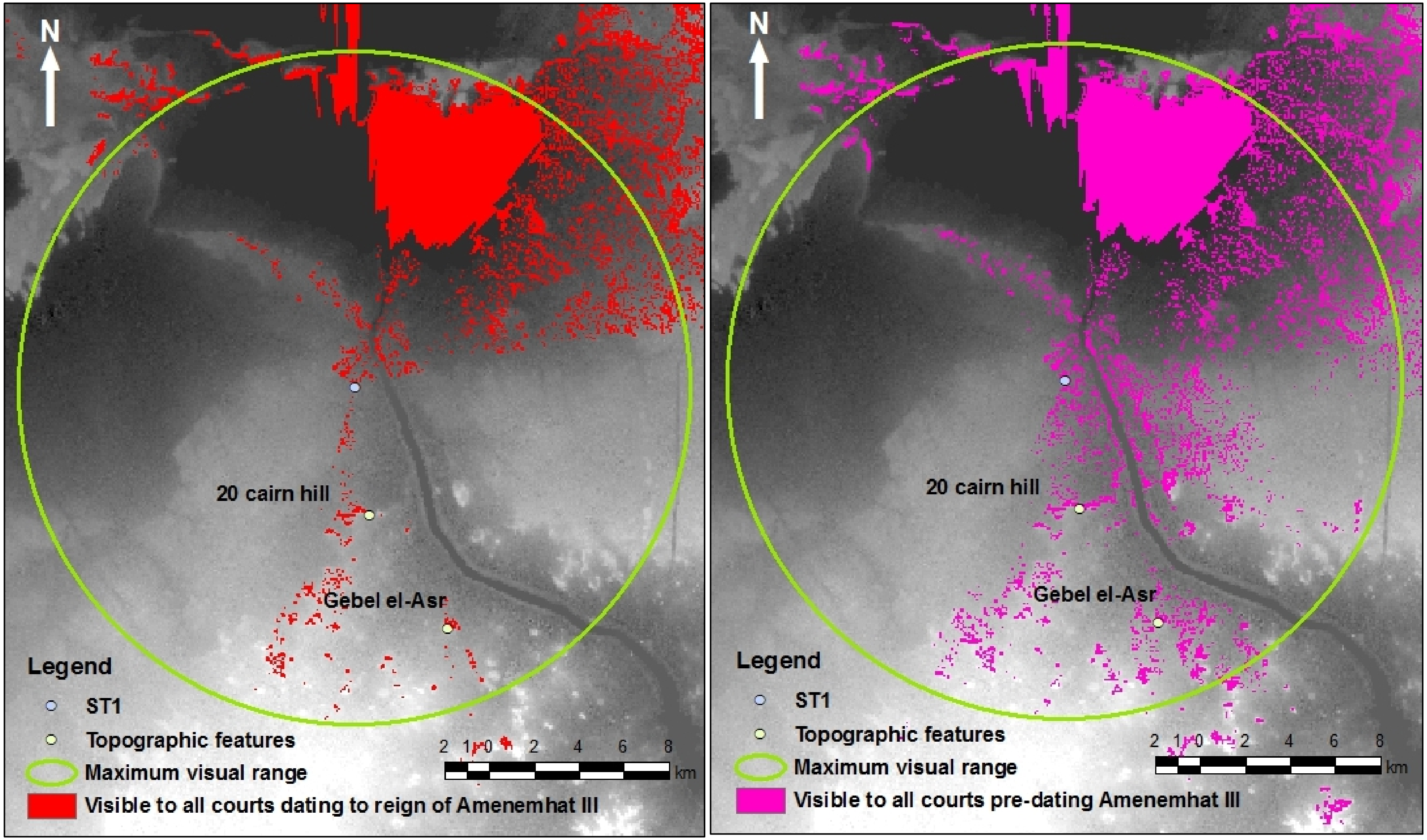


Fig 5.21: Comparison of the projective viewsheds visible to a) all courts dating to the reign of Amenemhat III (left); b) all courts pre-dating his reign (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

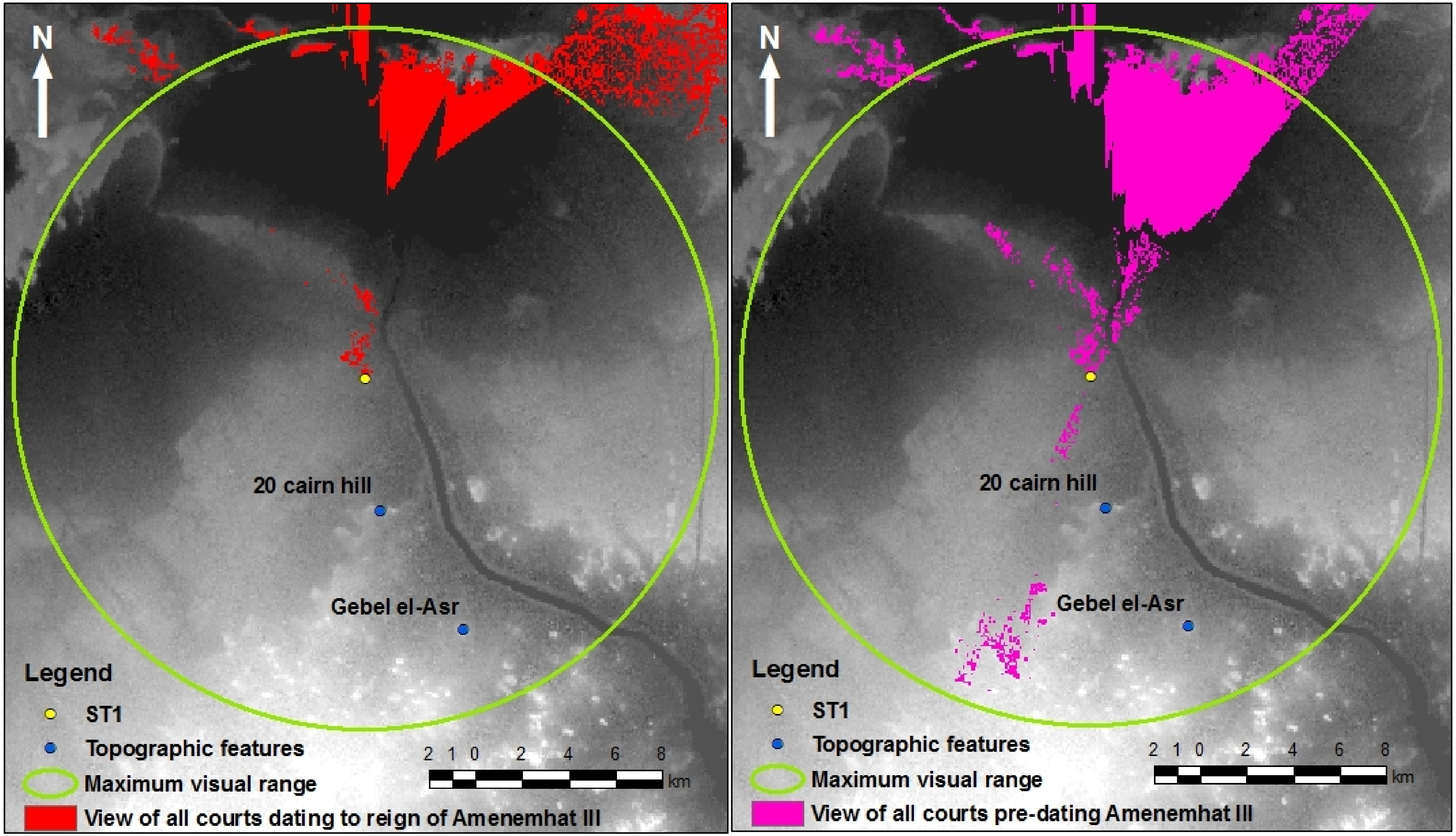


Fig 5.22: Comparison of the reflective viewshed where all courts a) dating to the reign of Amenemhat III (left); and b) pre-dating his reign (right) are visible. Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

The projective viewsheds of the two courts pre-dating the reign of Amenemhat III are quite similar (Fig 5.12 and Fig 5.14), resulting in a large projective viewshed for this group. However, their reflective viewsheds are quite different and the reflective viewshed for this group is quite restricted because of the small reflective viewshed of court VI. The differences between them suggest that there was no consistent approach to the visibility of cairn-courts before the reign of Amenemhat III and, given that the two courts belong to different reigns, the differences between them probably indicate that different imperatives governed the construction of each court.

5.1.3. Conclusion

Visibility analysis revealed several aspects of the visual relationship between the courts and the surrounding landscape. Given that all the structures are located on a ridge, it is not surprising that visibility of the courts was generally better than the view from them and only a very small area was visible from or had views of less than five courts. The limited area from which all courts were visible was due to the courts on Stelae Ridge north, particularly court VII. The poorer visibility of these courts suggested that good visibility was not always the highest priority for their builders.

Stelae Ridge south was generally more visible and had better views than Stelae Ridge north, but the differences between the two ridges were particularly pronounced in the reflective visibility analysis. The reflective viewsheds for courts on Stelae Ridge north were particularly limited and while parts of both 20 cairn hill and the Gebel el-Asr were visible from all the courts, they only had a view of the five courts on Stelae Ridge south. The viewsheds of the courts on Stelae Ridge north also exhibited more intra-ridge variation than those on Stelae Ridge south. Overall Stelae Ridge south appeared to be a far more visible topographic feature and it may be significant that it also has the earliest structures on it.

Queries of the observer points analysis confirmed that there was no consistent relationship between the artefacts or date of a court and the size or appearance of its viewsheds. The varied viewsheds associated with dry-stone courts excludes the possibility that the presence of a court structure was associated with a particular size or type of viewshed, but it is possible that there is some archaeological significance to the consistently large viewsheds associated with cairn III and the two pseudo-courts, which are all on Stelae Ridge south.

It was possible to differentiate between the courts on Stelae Ridge south based on the size and shape of their individual viewsheds. Although it is doubtful whether the slight differences between them would have been perceptible to human observers, there may be an association between the position of the court on the ridge and the size of its viewshed, with courts on the central crest being higher and having larger viewsheds. These slight differences in viewshed size may therefore reflect conscious choices about the position of a structure, rather than decisions made on the basis of its visibility.

The much more pronounced differences between the viewsheds associated with the different ridges and the variation between the viewsheds of courts VI-VIII on the northern ridge, are likely have been noticeable to the subjective observer and may therefore have directly influenced court location. These differences were apparent to the author when visiting the site, even though her visit was short and there was insufficient time to make a full record of the visibility from all the structures.

5.2. The effect of the azimuths upon visibility analysis of the courts.

In the absence of a detailed DEM which included the cairns, azimuths were used to model the effect of each cairn upon visibility of the court immediately adjacent to it.[258] The visibility analysis of the courts was re-run without the azimuths to assess the effect of them upon the results of it and identify any patterns relating to the visibility of Stelae Ridge prior to the construction of the cairns.

Subsequent tables are organised in the same format as in the preceding sections, but for clarity the numbers have been coloured to indicate whether the figures are lower or higher in the viewsheds without azimuths. Blue numbers indicate a lower figure and red numbers indicate a higher figure in the viewshed without azimuths.

5.2.1. Cumulative viewshed analysis without azimuths

The results of the projective and reflective cumulative viewshed analysis undertaken without azimuths are quantified in Table 5.8 and Chart 5.2. The projective cumulative viewshed is shown in Fig 5.23 and the reflective cumulative viewshed in Fig 5.24.

[258] For how the azimuths were created and used see Chapter 2, section 2.6.3.

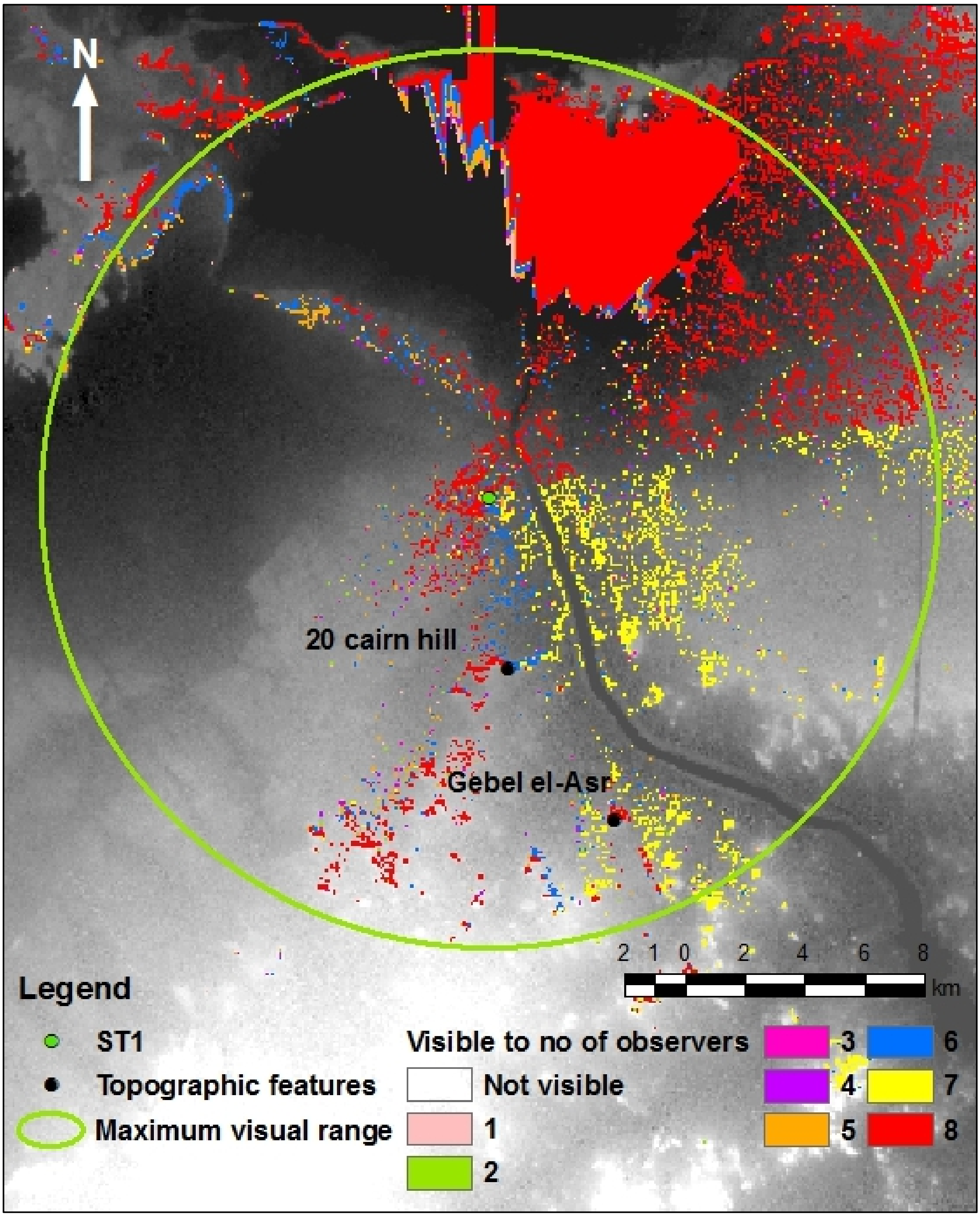


Fig 5.23: Results of the projective cumulative viewshed analysis calculated without azimuths. The viewshed shows how many observers, located in the courts of cairns I to VIII, can see the landscape around Stelae Ridge. The viewshed is shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

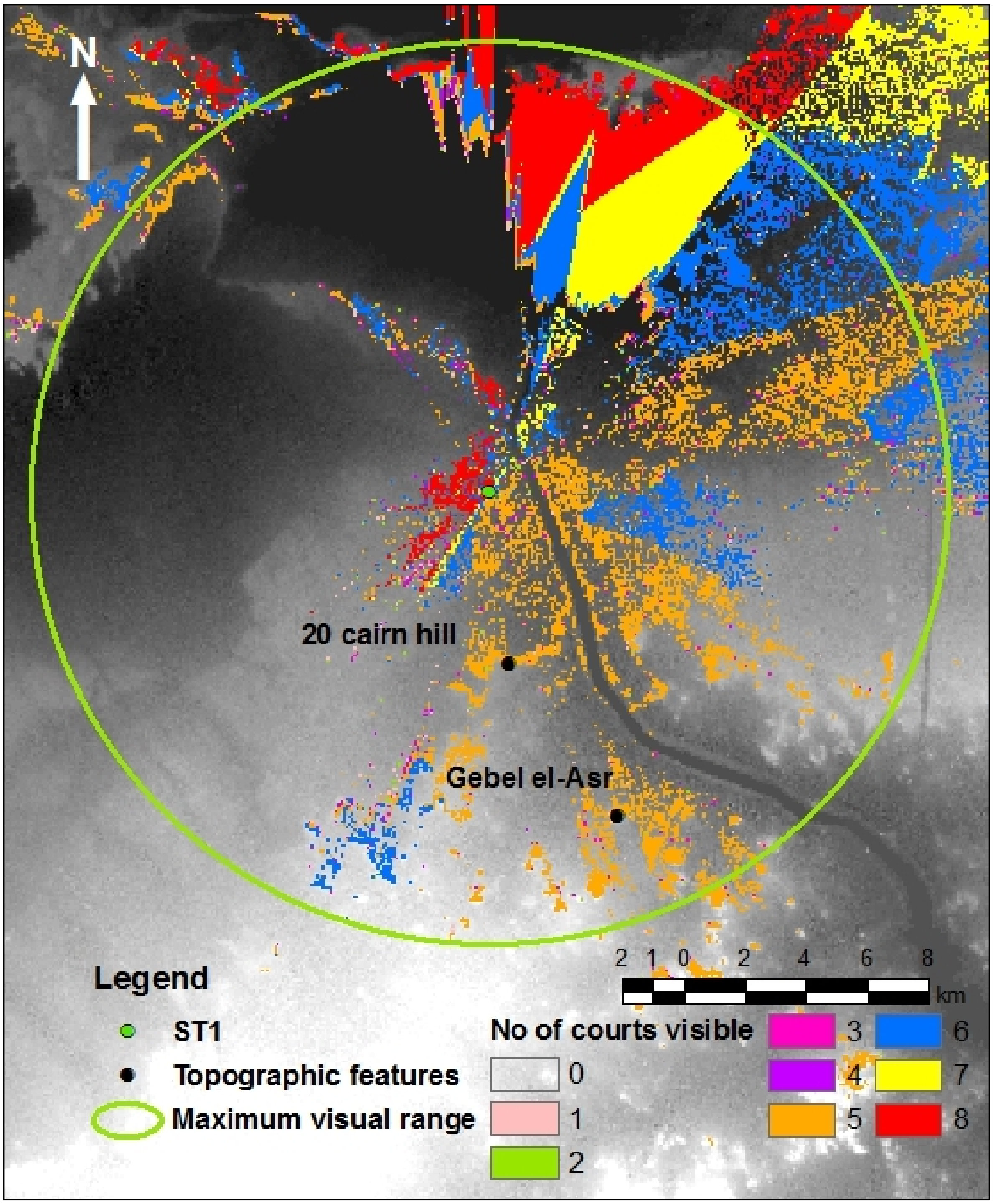
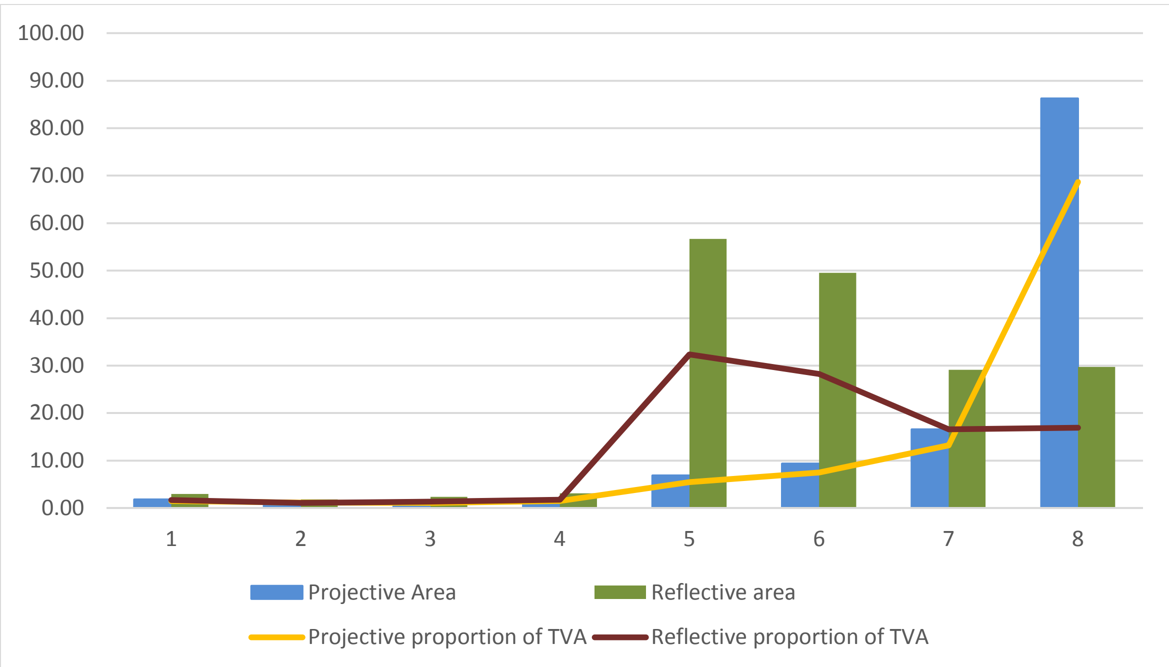


Fig 5.24: Results of the reflective cumulative viewshed analysis calculated without azimuths. The viewshed shows how many courts could be seen from the landscape around Stelae Ridge. The viewshed is shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

Table 5.8: Areas of projective and reflective cumulative viewsheds of the courts calculated without azimuths.

Number of courts	Projective			Reflective		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)		Number	Area (km^2)	
1	246	1.84	1.46	396	2.96	1.69
2	198	1.48	1.18	248	1.85	1.06
3	181	1.35	1.08	313	2.34	1.34
4	244	1.82	1.45	414	3.09	1.77
5	921	6.88	5.48	7581	56.67	32.34
6	1252	9.36	7.45	6625	49.52	28.26
7	2219	16.59	13.21	3893	29.10	16.61
8	11542	86.28	68.69	3973	29.70	16.95
Any	16803	125.61	100.00	23443	175.25	100.00
<5	869	6.50	5.17	1371	10.25	5.85
>=6	15013	112.23	89.35	14491	108.33	61.81
>=5	15934	119.11	94.83	22072	165.00	94.15

Chart 5.2. The areas of the projective and reflective cumulative viewsheds calculated without azimuths, by number of courts. Bars show area in km^2 and lines show percentage of the total visible area (Data taken from Table 5.8).



Comparison of the cumulative viewsheds with and without azimuths shows that the overall patterns remained the same, indicating that these patterns are unlikely to be artificial artefacts of the azimuths and represent genuine aspects of the visibility from the Stelae Ridge courts:

- The sizes of the cumulative viewsheds for five courts remained relatively consistent.
- The areas of the projective cumulative viewsheds steadily increase with the number of courts.
- The reflective cumulative viewsheds show sudden increase in viewshed area where five courts are visible, followed by decreasing viewshed sizes for five, six, seven and eight courts.

Removing the azimuths also resulted in a number of differences compared to the cumulative viewshed with azimuths. It increased the total visible area and the areas of the cumulative viewsheds for more than four courts, because the cumulative viewsheds without azimuths included previously excluded areas of landscape to the west of the cairns.

For cumulative viewsheds of up to four courts, removing the azimuths also reduced the viewshed size and produced more consistent viewsheds. This is due to the precise effect of the azimuths on visibility and the different angles of the azimuths at each court. As the cairns are not perfectly aligned and have a slightly different shape from each other in Engelbach's plan, visibility to the west of each cairn is constrained by a different pair of azimuths, often at different angles to the azimuths of other cairns. This creates areas of the viewsheds that are inter-visible with some cairns, but not all of them, producing a striped appearance to the south-west of Stelae Ridge in the cumulative viewsheds with azimuths (Fig 5.1 and Fig 5.2). This creates artificial variation and falsely inflates the sizes of the cumulative viewsheds of up to four courts. Fig 5.25 compares the projective cumulative viewshed analysis for up to four courts calculated with and without azimuths. It shows very clearly how removing the azimuths reduced the south-west to north-east alignments in the area to the south-west of Stelae Ridge. A similar effect was visible in the reflective cumulative viewsheds.

Overall, it is likely that the cairns would have obscured some of the landscape in accordance with the model provided by the azimuths, but the azimuths are likely to have exaggerated the size of these areas because they cannot model the variable visibility along the sloping sides of the cairns. Real visibility is likely to lie somewhere between the results of the analysis with azimuths and the results of the analysis without azimuths.

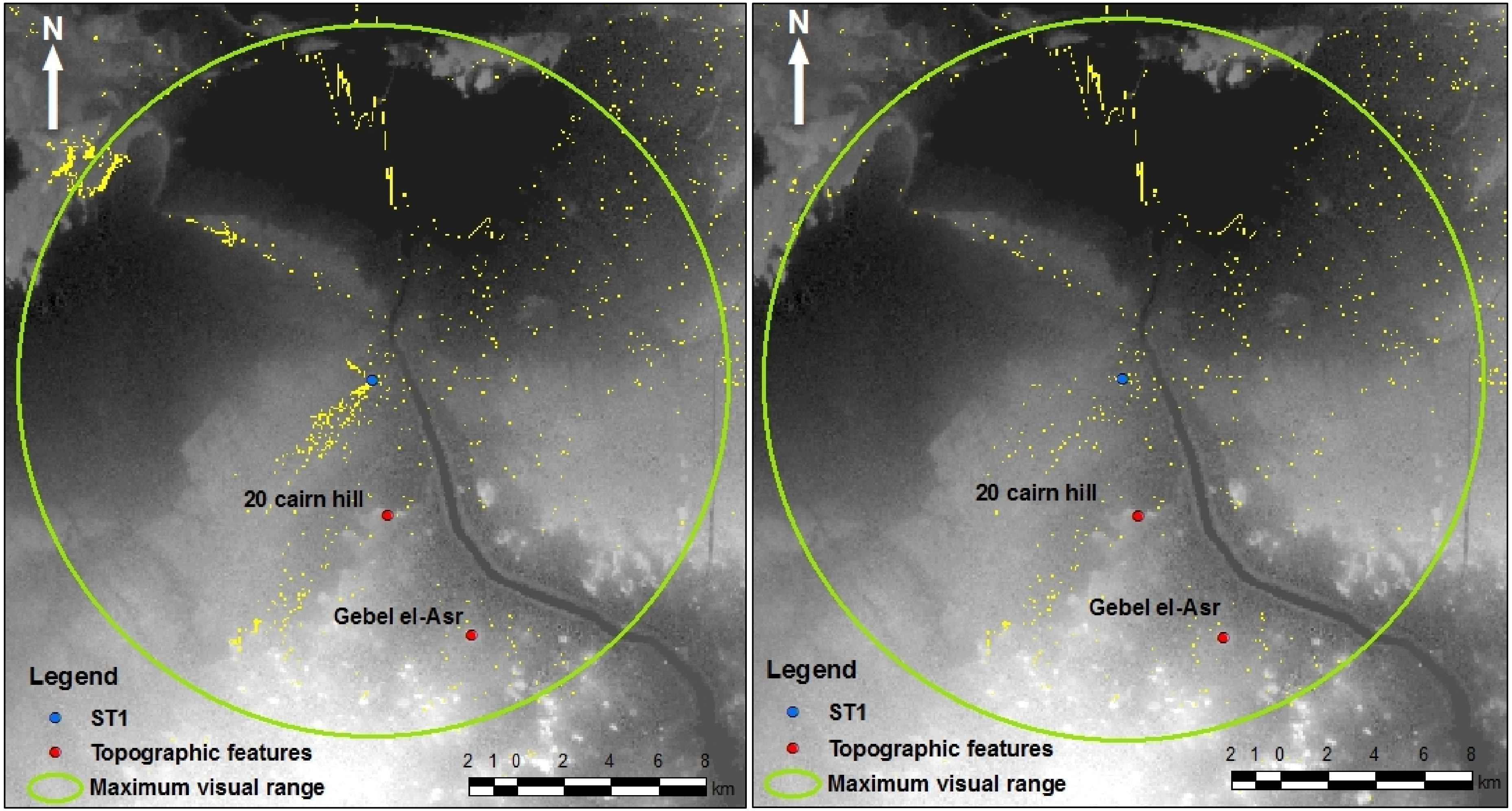


Fig 5.25: Comparison of the projective cumulative viewsheds for up to four courts calculated with azimuths (left) and without azimuths (right). The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

5.2.2. Observer points analysis without azimuths

The observer points analysis of the courts was also run without azimuths, and inclusive and exclusive viewsheds for each court and ridge were extracted. No viewsheds were extracted for the groups of courts with the same artefacts, court structure or date because no relationship had been found between these aspects of the courts and their viewsheds in the visibility analysis with azimuths. Since the cumulative viewshed analysis without azimuths indicated that the general patterns remained consistent whether or not azimuths were used, extracting the viewsheds of groups defined by artefact type, court structure or reign was unlikely to produce any additional evidence.

Exclusive viewsheds of each court.

The cumulative viewshed analysis without azimuths indicated that the azimuths artificially increased the sizes of the cumulative viewsheds associated with small numbers of courts. The exclusive viewsheds of each court would be subject to similar artificial inflation, so the observer points analysis without azimuths was queried to identify the exclusive projective and reflective viewsheds for each court, for comparison with the visibility analysis with azimuths. Fig 5.26 shows the exclusive projective and reflective viewsheds for each court and the sizes of the viewsheds are quantified in Table 5.9.

The reflective exclusive viewsheds are larger than the projective and both are widely dispersed. There is no obvious consistent or cohesive area visible to any one court. However, removing the azimuths has largely eliminated the alignments located to the south-west of Stelae Ridge in Fig 5.6, confirming that these alignments are a product of the azimuths and not of the underlying topography. Removing the azimuths has also reduced the sizes of the viewsheds in general, although there are some exceptions. Where the viewsheds have reduced in size, this probably reflects the removal of the alignments. Where they have increased, this represents the addition of new areas that were previously excluded from the visibility analysis by the azimuths.

Next page, Fig 5.26: Projective and reflective exclusive viewsheds calculated without azimuths a) Areas exclusively visible to each observer point in each court (left) and b) areas where only one observer point, in one court, was visible (right). Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

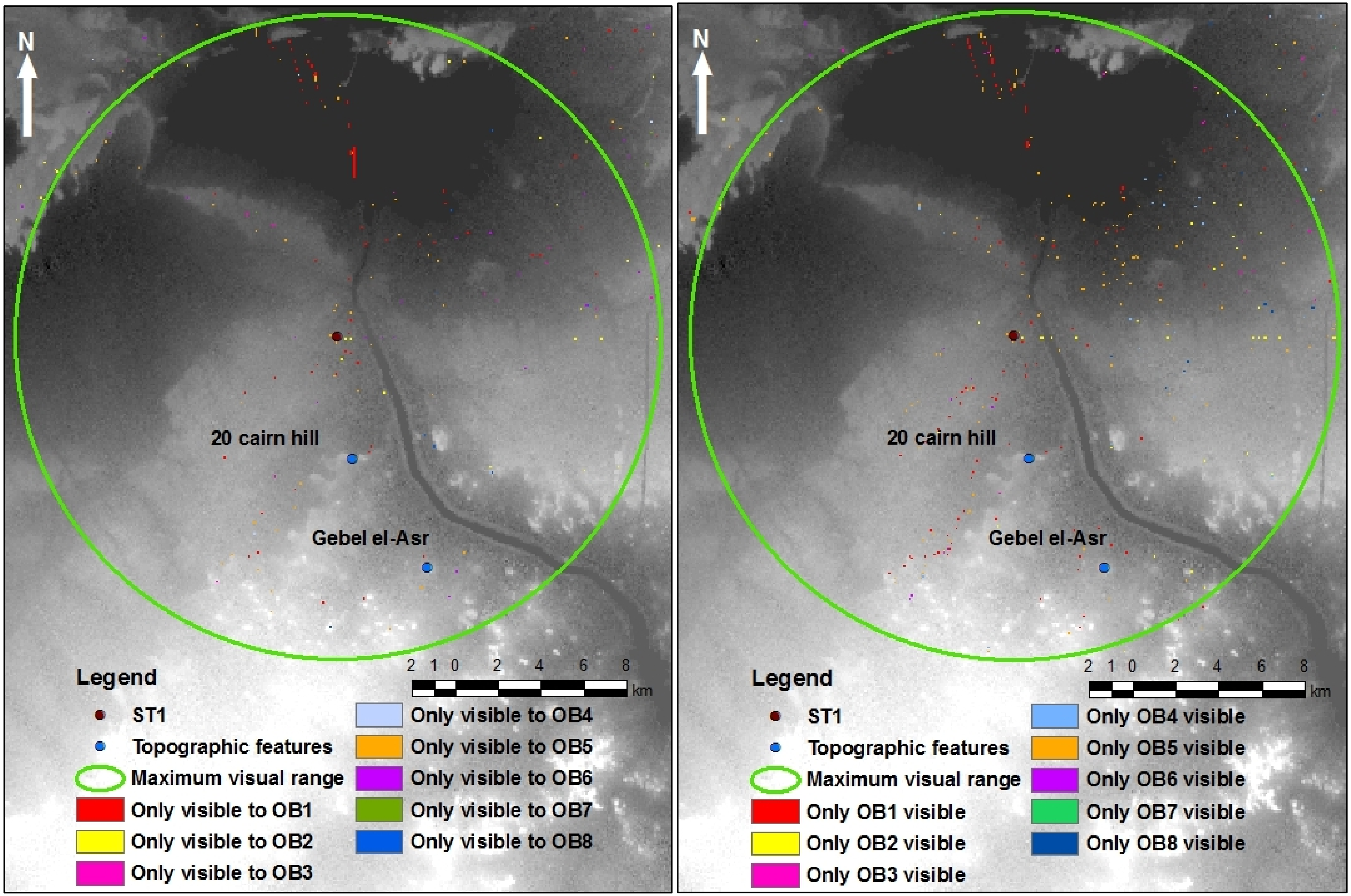

N
20 cairn hill
Gebel el-Asr
2 1 0 2 4 6 8
km
Legend
ST1
Topographic features
Maximum visual range
Only visible to OB1
Only visible to OB2
Only visible to OB3
Only visible to OB4
Only visible to OB5
Only visible to OB6
Only visible to OB7
Only visible to OB8
N
20 cairn hill
Gebel el-Asr
2 1 0 2 4 6 8
km
Legend
ST1
Topographic features
Maximum visual range
Only OB1 visible
Only OB2 visible
Only OB3 visible
Only OB4 visible
Only OB5 visible
Only OB6 visible
Only OB7 visible
Only OB8 visible

Table 5.9: Sizes of exclusive projective and reflective viewsheds for each court calculated without azimuths.

Observer Point	Court	Projective			Reflective		
		Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
		Number	Area (km^2)		Number	Area (km^2)	
OB1	I	92	0.69	0.55	131	0.98	0.56
OB2	II	28	0.21	0.17	47	0.35	0.20
OB3	III	17	0.13	0.10	23	0.17	0.10
OB4	IV	4	0.03	0.02	30	0.22	0.13
OB5	V	66	0.49	0.39	139	1.04	0.59
OB6	VI	26	0.19	0.15	10	0.07	0.04
OB7	VII	5	0.04	0.03	2	0.01	0.01
OB8	VII	8	0.06	0.05	14	0.10	0.06
Total	**All**	**246**	**1.84**	**1.46**	**396**	**2.96**	**1.69**

Stelae Ridge north and Stelae Ridge south

The visibility analysis with azimuths concluded that there were significant differences between the different ridges. The courts on Stelae Ridge south were found to have large and consistent projective and reflective viewsheds. The courts on Stelae Ridge north had much smaller viewsheds, particularly reflective viewsheds, and they also exhibited more intra-ridge variability in size and consistency.

Projective and reflective viewsheds for all the courts on each ridge were extracted from the observer points analysis without azimuths to assess whether the azimuths had had any effect upon the visibility analysis. The projective viewsheds for each ridge are shown in Fig 5.27 and the reflective viewsheds in Fig 5.28. Table 5.10 details their areas.

The overall patterns in the viewsheds for all courts on each ridge remained the same without azimuths, indicating that the following patterns are likely to represent genuine aspects of the visibilities of the Stelae Ridge ridges. If perceptible, these patterns may have influenced the builders of the structures as to the location of the cairn-courts:

- The projective and reflective viewsheds of Stelae Ridge south are larger than those of Stelae Ridge north.
- The difference in the size is far greater in the reflective viewshed than in the projective viewshed.

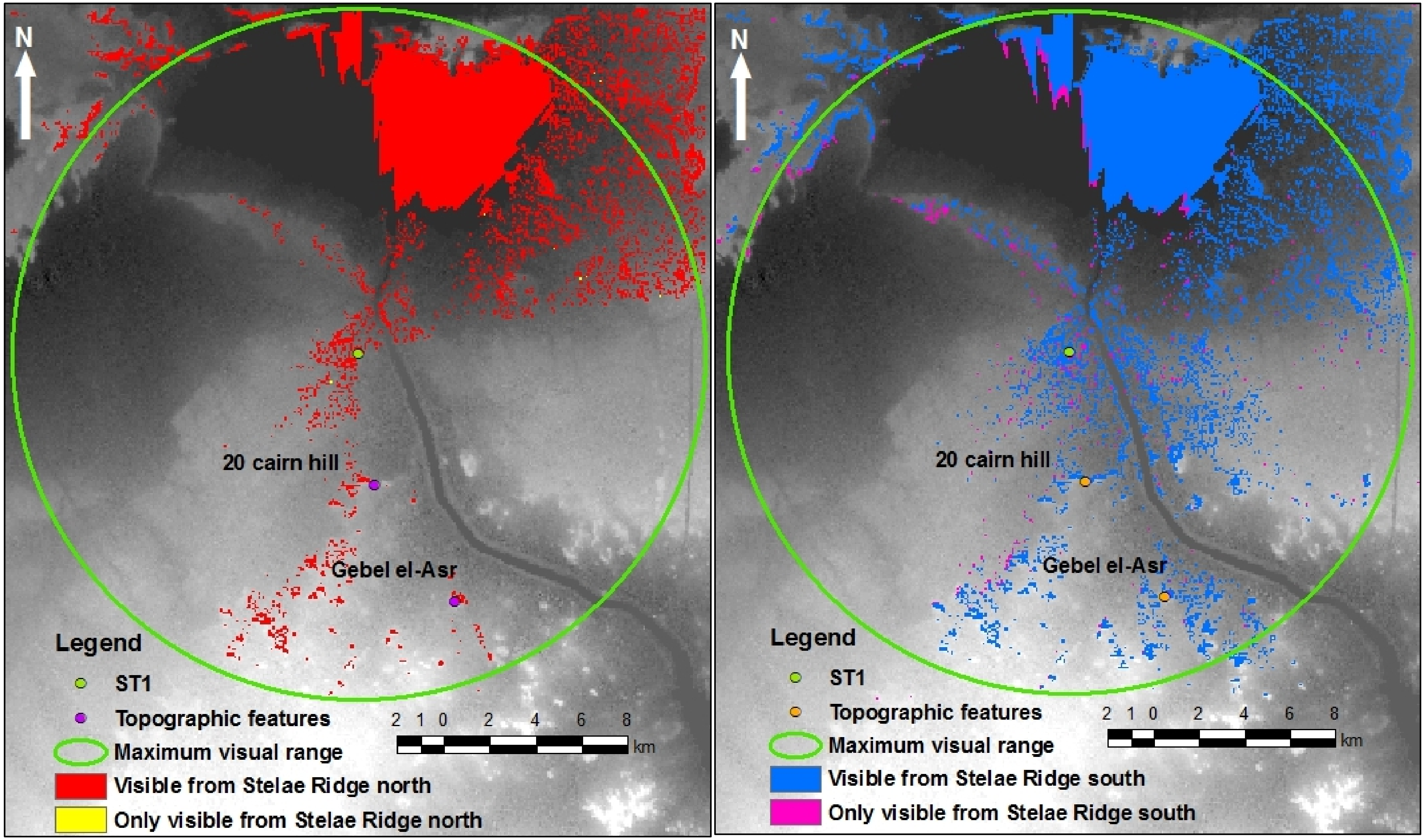


Fig 5.27: Projective viewsheds calculated without azimuths for all the courts on each ridge a) Inclusive (red and yellow) and exclusive (yellow only) viewshed for Stelae Ridge north (left), and b) Inclusive (blue and pink) and exclusive (pink only) viewshed for Stelae Ridge south (right). Viewsheds shown overlying SRTM tilen22_e031_3arc_v2 (SRTM from the USGS)

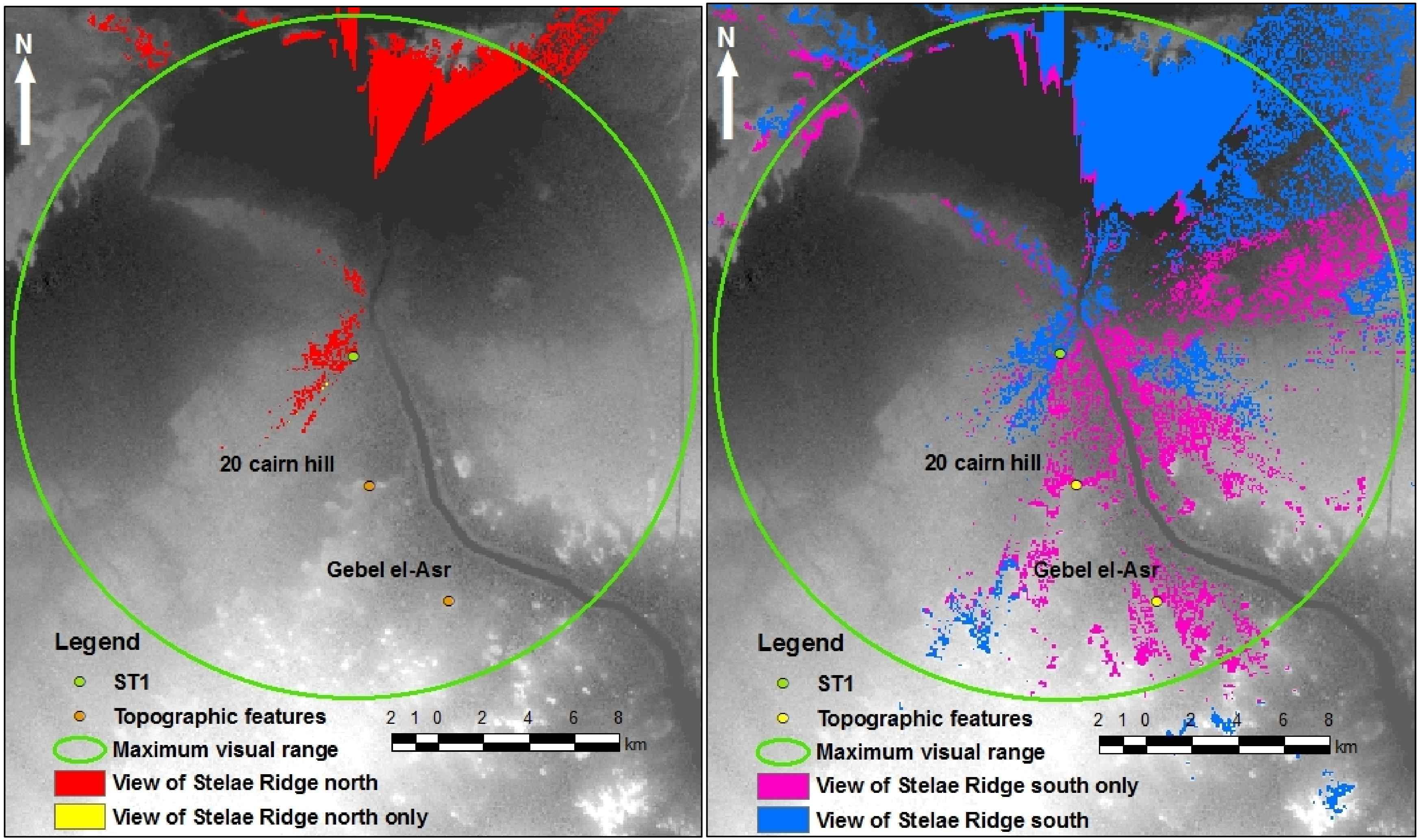


Fig 5.28: Reflective viewsheds calculated without azimuths for all the courts on each ridge a) Inclusive (red and yellow) and exclusive (yellow only) viewshed for Stelae Ridge north (left), and b) Inclusive (blue and pink) and exclusive (pink only) viewshed for Stelae Ridge south (right). Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM from the USGS).

Table 5.10: Sizes of exclusive and inclusive projective and reflective viewsheds for all the courts on each ridge, calculated without azimuths.

		Projective			Reflective		
		Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
Ridge	Courts	Number	Area (km²)		Number	Area (km²)	
North Exclusive	VI, VII and VIII	8	0.06	0.05	4	0.03	0.02
North Inclusive		11627	86.92	69.20	4014	30.01	17.12
South Exclusive	I-V	829	6.20	4.93	7512	56.16	32.04
South Inclusive		15763	117.83	93.81	21967	164.21	93.70

- The inclusive viewsheds for Stelae Ridge north closely resemble the cumulative viewsheds for eight courts, indicating that the cumulative viewshed is constrained by the viewshed of one or more of the courts on Stelae Ridge north.
- The inclusive viewsheds for Stelae Ridge south closely resemble the cumulative viewshed for five courts.
- While Stelae Ridge south had a better view of the surrounding landscape than Stelae Ridge north, it was also *much* more visible. The large exclusive reflective viewshed for Stelae Ridge south indicates there was a large area of the landscape with no visibility of Stelae Ridge north.

Although the general patterns in the data remain consistent, removing the azimuths did have an effect. Apart from the very small exclusive reflective viewshed for Stelae Ridge north, removing the azimuths increased the size of all the viewsheds for both ridges because the area to the west of Stelae Ridge was included in the visibility analysis. This area includes much of the mining zone and forms a significant component of the reflective viewshed for Stelae Ridge north. While this is unlikely to be significant for visibility of the courts, since the cairns would have obscured them from view, it may be more significant for visibility of the cairns, which are likely to be equally, if not more, visible.

Viewsheds of individual courts

Viewsheds for each court were extracted from the observer points analysis without azimuths to determine the influence of the azimuths upon the size and shape of these viewsheds. The inclusive projective and reflective viewsheds for each court, without azimuths, are shown in Fig 5.29 to Fig 5.36 and are quantified in Table 5.11.

Table 5.11: Comparison of the sizes of inclusive projective and reflective viewsheds for each court, calculated without azimuths.

Observer Point	Court	Projective			Reflective		
		Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
		Number	Area (km^2)		Number	Area (km^2)	
OB1	I	16255	121.51	96.74	22712	169.78	96.88
OB2	II	16221	121.26	96.54	22595	168.91	96.38
OB3	III	16229	121.32	96.58	22681	169.55	96.75
OB4	IV	16280	121.70	96.89	22744	170.02	97.02
OB5	V	16261	121.56	96.77	22735	169.95	96.98
OB6	VI	15221	113.78	90.59	9108	68.09	38.85
OB7	VII	11757	87.89	69.97	5074	37.93	21.64
OB8	VIII	13923	104.08	82.86	12528	93.65	53.44
TVA	Any	16803	125.61	100.00	23443	175.25	100.00

The overall patterns in the viewsheds remained the same with and without azimuths, indicating that these patterns are unlikely to be artificial artefacts of the azimuths and represent genuine aspects of the visibilities of the courts, which may have influenced the choice of court location:

- Courts I-V on Stelae Ridge south have larger viewsheds than courts VI-VIII on Stelae Ridge north.
- The projective and reflective viewsheds for courts I-V are more consistent with each other in size and appearance than the viewsheds of courts VI-VIII. The reflective viewsheds for courts VI-VIII are the most variable of all.
- The reflective viewsheds for courts I-V are larger than the equivalent projective viewsheds, while the reflective viewsheds for courts VI-VIII are smaller than the equivalent projective viewsheds.
- Court VII has the smallest projective and reflective viewshed of all the courts.
- When the courts are ranked by viewshed size, courts VI-VIII have the same order with or without azimuths. Court VII has the smallest viewsheds, followed by court VIII and court VI, with the largest.

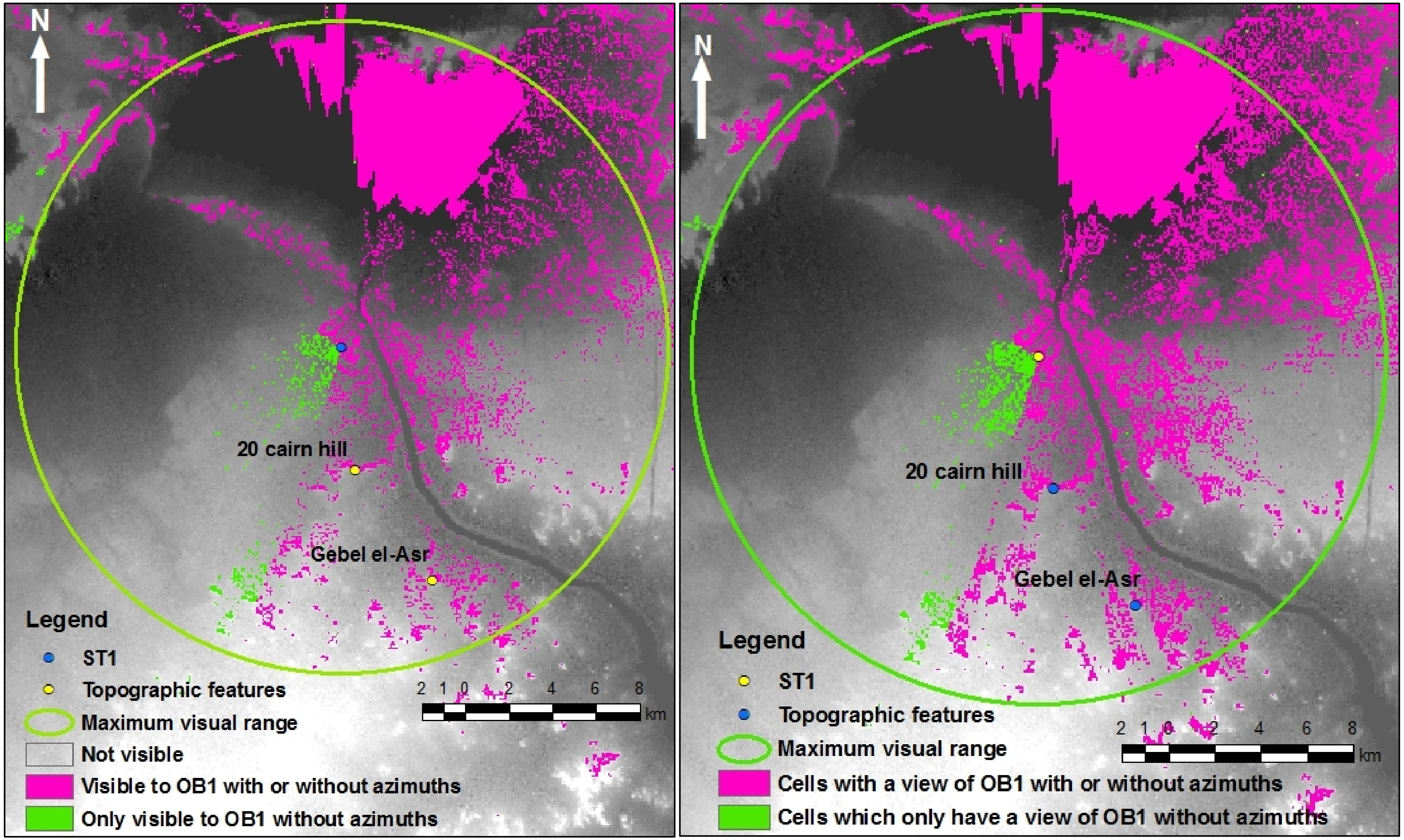


Fig 5.29: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OBI in court I on Stelae Ridge south, showing the difference between the viewsheds with azimuths (pink) and the viewsheds without azimuths (both pink and green). The green area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

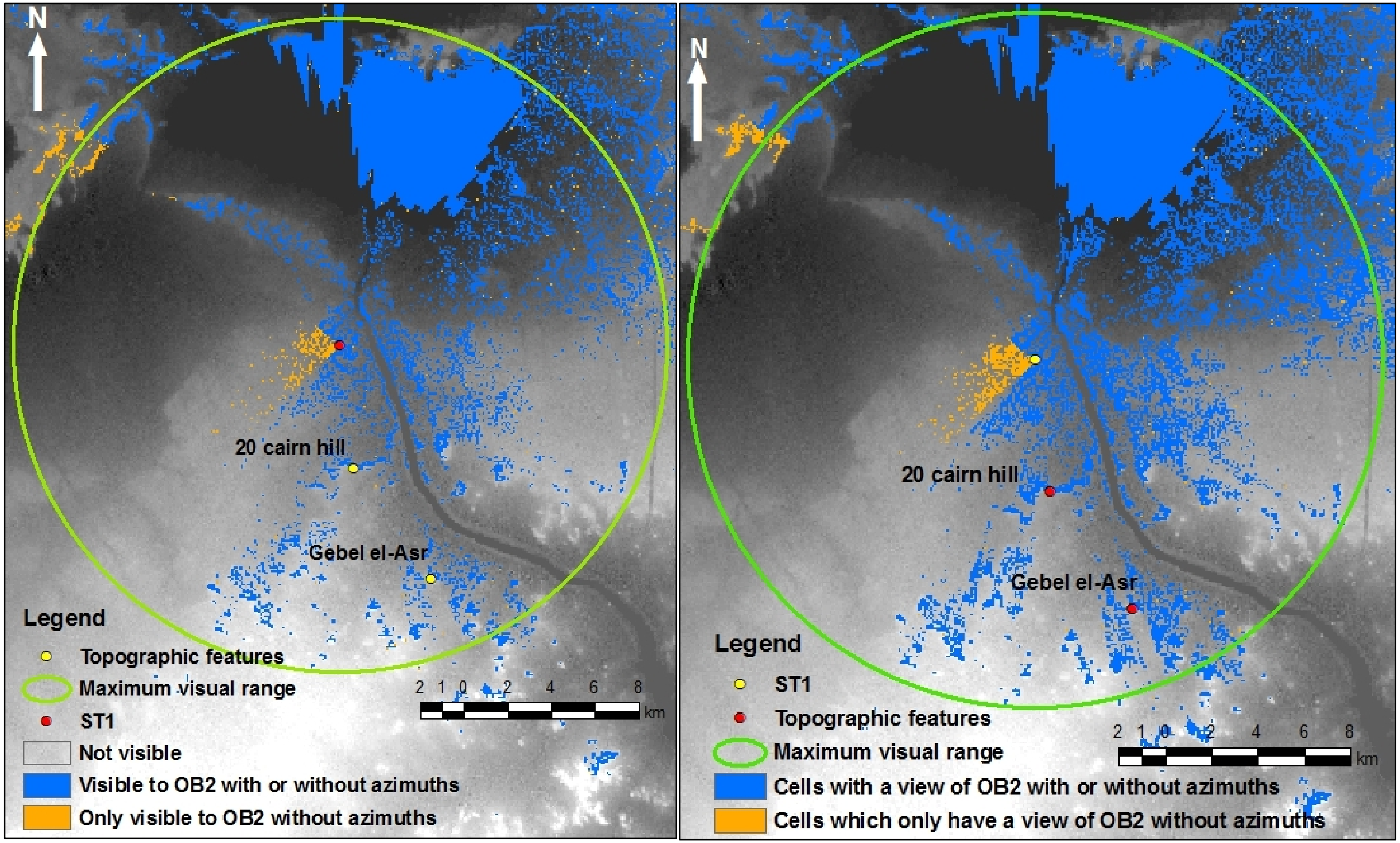


Fig 5.30: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB2 in court II on Stelae Ridge south, showing the difference between the viewsheds with azimuths (blue) and the viewsheds without azimuths (both blue and orange). The orange area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

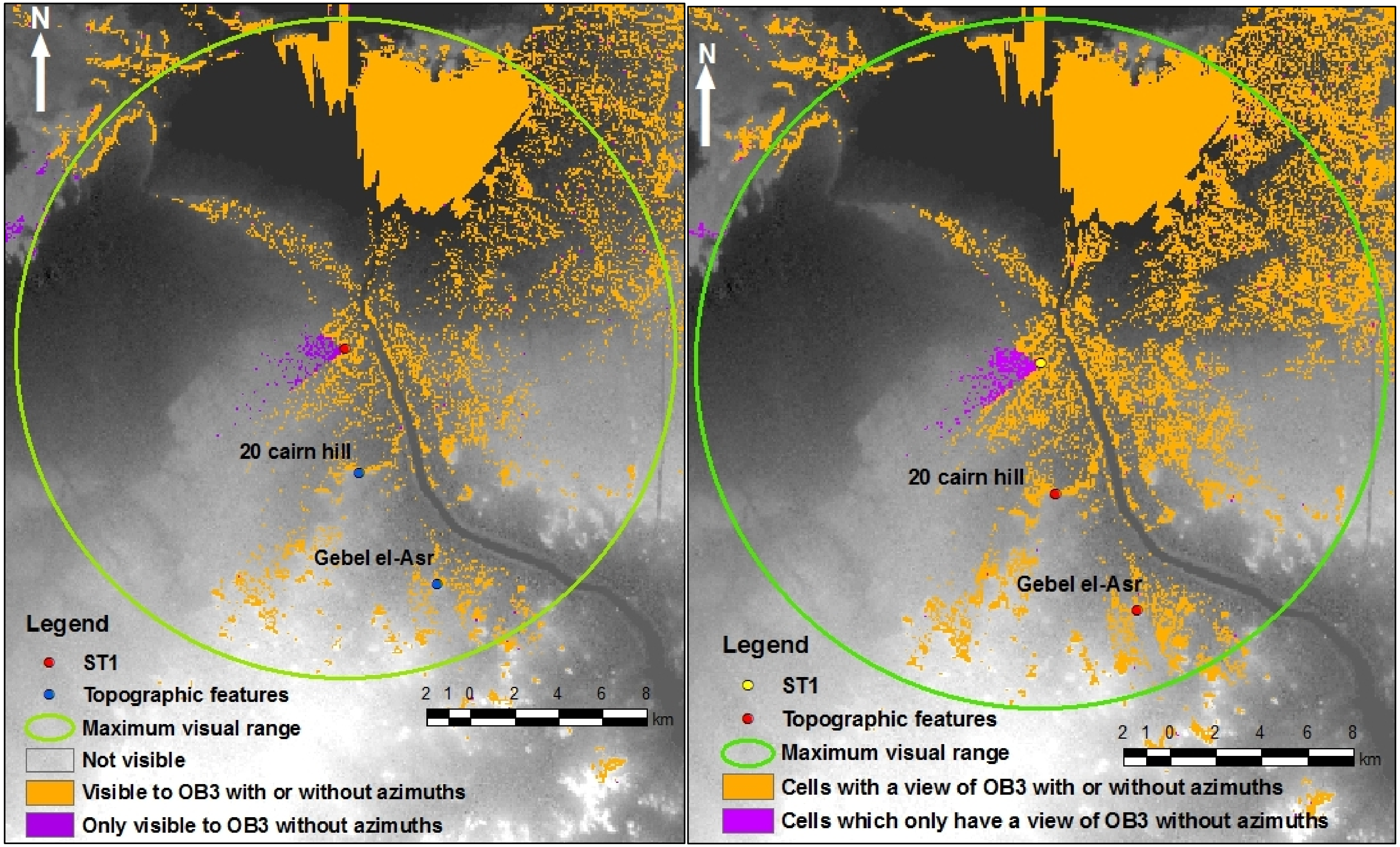


Fig 5.31: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB3, east of cairn III on Stelae Ridge south, showing the difference between the viewsheds with azimuths (orange) and the viewsheds without azimuths (both purple and orange). The purple area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

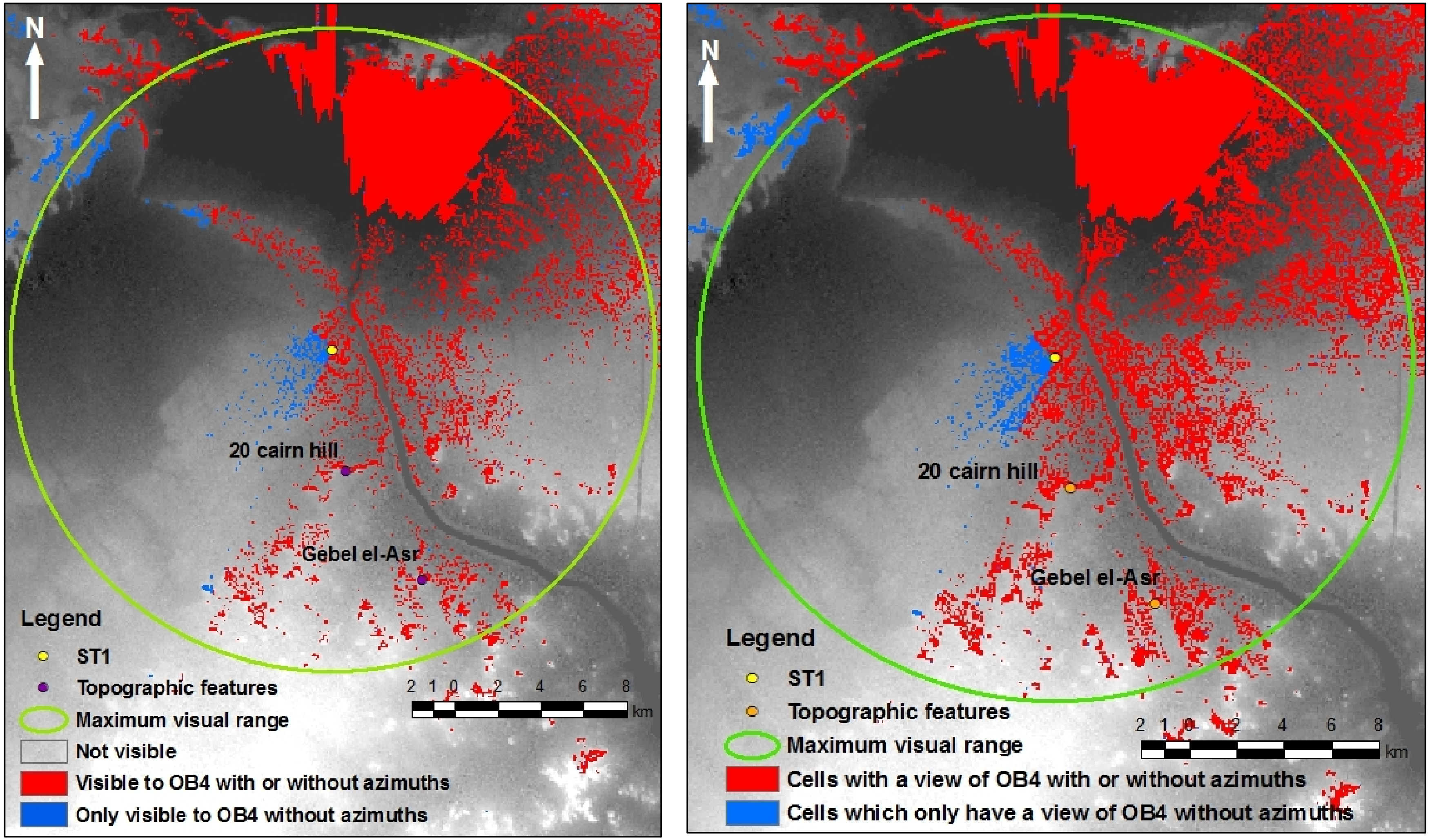


Fig 5.32: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB4 in court IV on Stelae Ridge south, showing the difference between the viewsheds with azimuths (red) and the viewsheds without azimuths (both blue and red). The blue area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

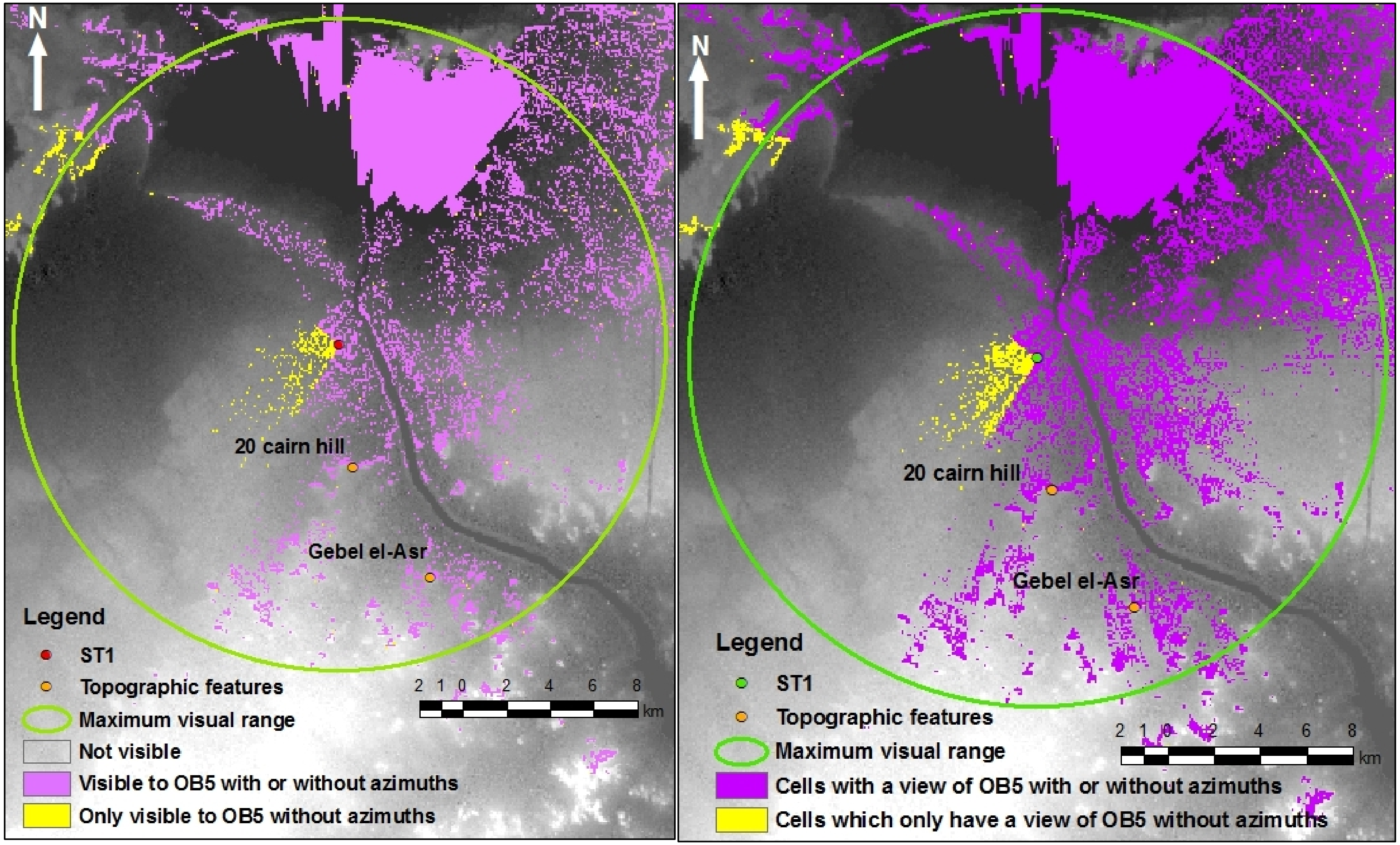


Fig 5.33: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB5 in court V on Stelae Ridge south, showing the difference between the viewsheds with azimuths (mauve) and the viewsheds without azimuths (both yellow and mauve). The yellow area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

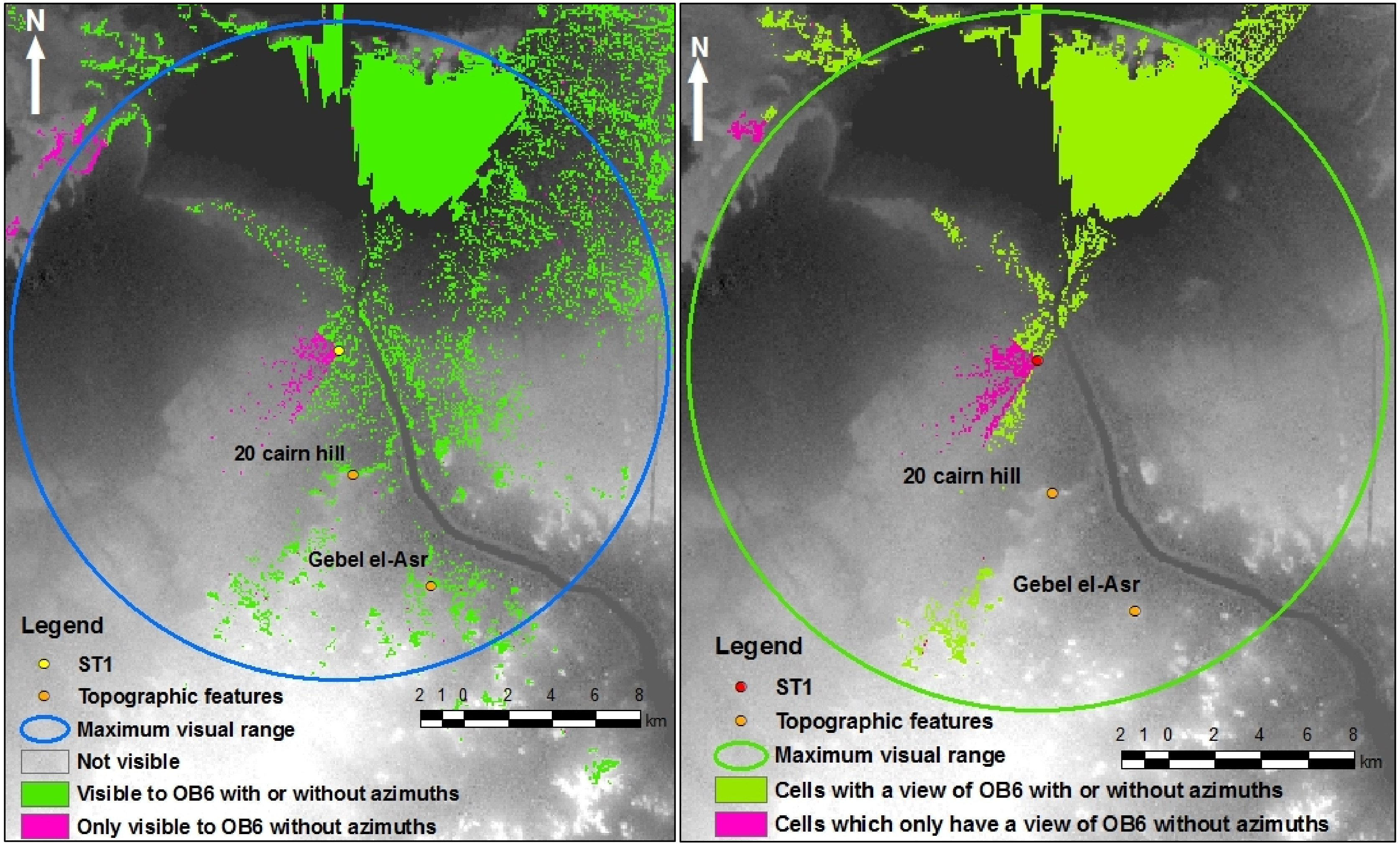


Fig 5.34: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB6 in court VI on Stelae Ridge north, showing the difference between the viewsheds with azimuths (green) and the viewsheds without azimuths (both pink and green). The pink area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

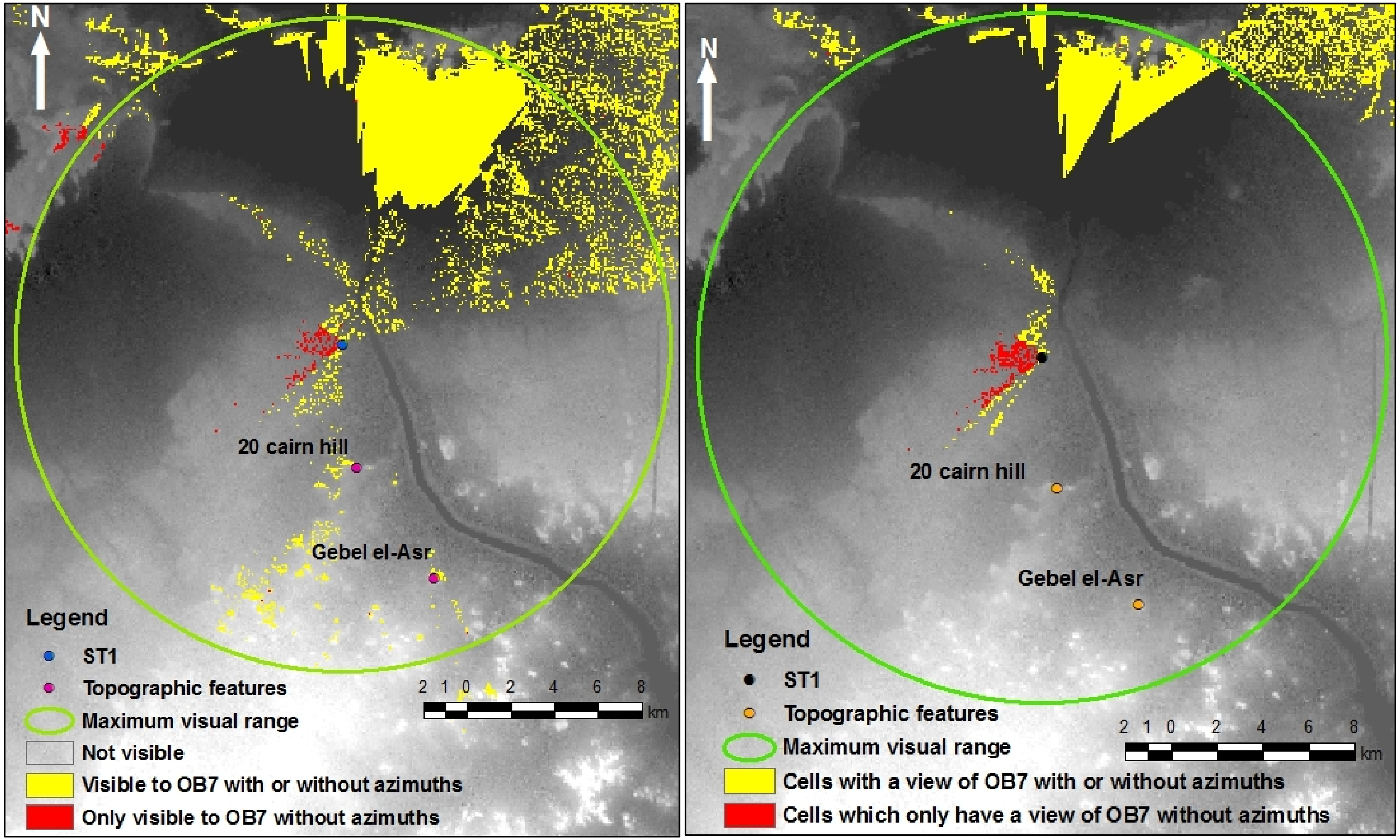
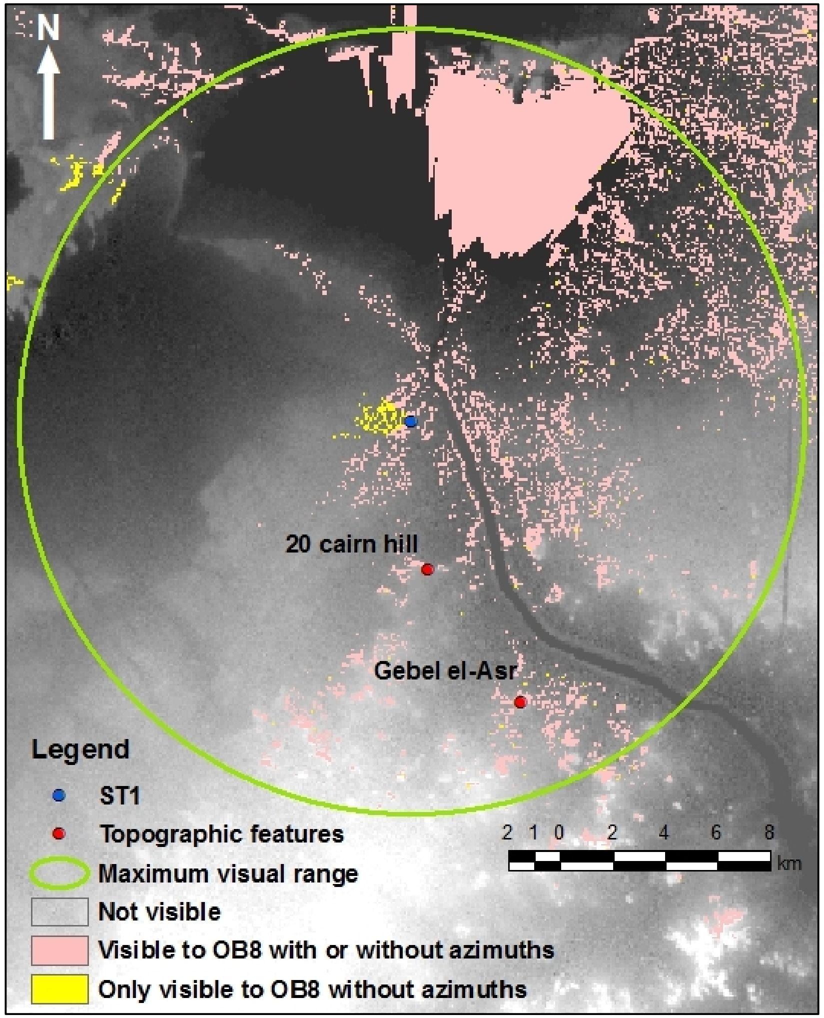


Fig 5.35: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB7 in court VII on Stelae Ridge north, showing the difference between the viewsheds with azimuths (yellow) and the viewsheds without azimuths (both yellow and red). The red area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).



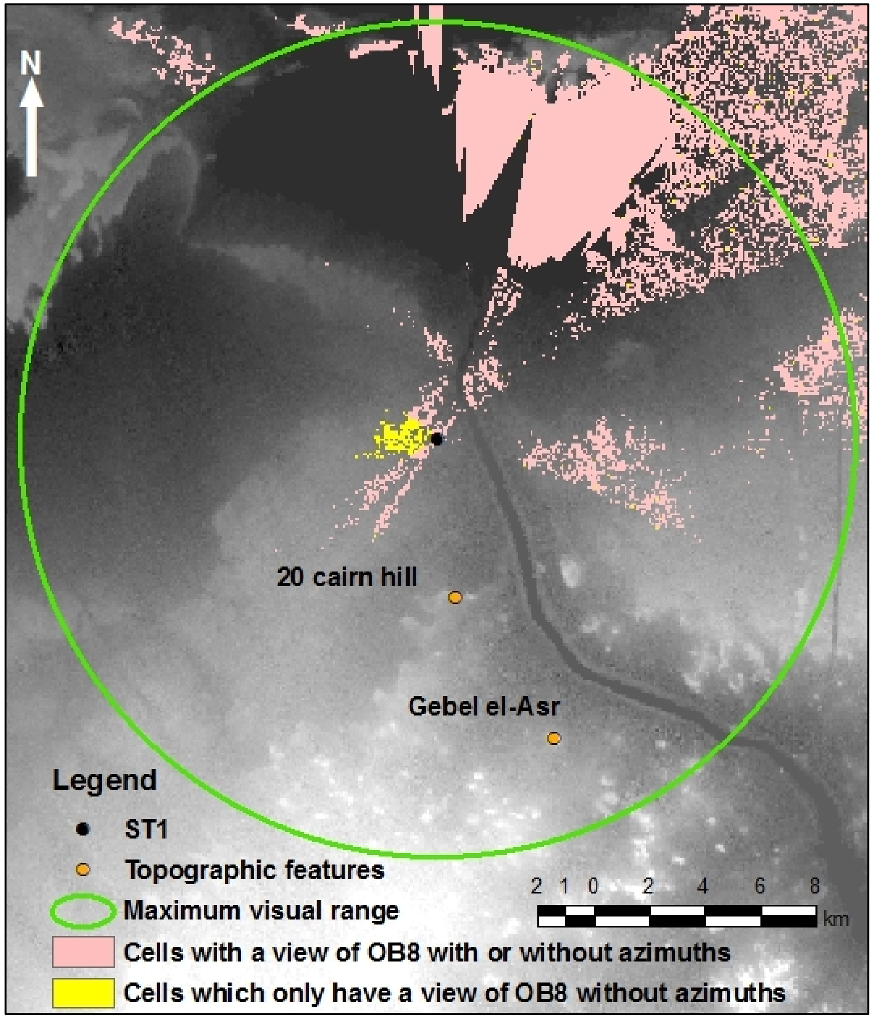


Fig 5.36: a) Projective (left) and b) Reflective (right) inclusive viewsheds for OB8 in court VIII on Stelae Ridge north, showing the difference between the viewsheds with azimuths (pink) and the viewsheds without azimuths (both yellow and pink). The yellow area is not visible to the viewsheds with azimuths. The viewsheds are shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

However, there were several differences between the analyses with and without azimuths. Removing the azimuths increased the size of all the viewsheds and reduced the variation between the viewsheds of courts I-V. This was particularly true of the projective viewsheds but also applied to the reflective viewsheds. Removing the azimuths slightly increased variation in the projective viewsheds for courts VI-VIII, while variation in the size of the reflective viewsheds decreased very slightly.

Removing the azimuths also altered the ranking of courts I-V by viewshed size. In the analysis with azimuths, OB3 had the largest viewshed on the southern ridge in both the projective and reflective visibility analysis and court IV had the smallest.[259] Without azimuths court IV had the largest viewshed and court II had the smallest on the southern ridge. Court V was second largest, court I was third and OB3 was fourth. Removing the azimuths had this effect because the viewsheds of courts I-V are so similar in size that slight changes in the size of the viewshed can have a disproportionate effect. The results of the visibility analysis without azimuths provide a useful control for the effect of the azimuths upon the ranking of the courts.

While the viewsheds calculated without azimuths were larger in area, they did not show a universal increase in the proportion of the total visible area occupied by each viewshed. Although the difference between the percentages is very small, the percentage of the total visible area occupied by the viewsheds of OB3, east of cairn III, and court VIII actually decreased slightly when calculated without azimuths. This is because the increase in the size of the viewsheds was proportionally smaller than the increase in the total visible area and it suggests that for OB3 and court VIII the azimuths did not have such a large impact upon the size of their viewsheds. This is explained by the particular observer location and azimuth angles of these courts.[260] The angle excluded from the visibility analysis by the azimuths was smaller for OB3 and court VIII than for the other courts. This is clearly visible in Fig 5.37, which shows the 68.62° area excluded from the reflective viewshed of OB3 by the azimuths, compared to the 110.39° area excluded from the viewshed of OB4, the largest angle excluded from the viewshed of any court by the azimuths. Removing the azimuths from the analysis therefore had much less effect upon the size of the viewsheds for OB3 and VIII than it did for the other courts, and their viewsheds increased by a commensurately smaller amount. This amount was too small in comparison to the increase in the total visible

[259] For the sizes of the viewsheds without azimuths see Table 5.4 and for the viewsheds see Fig 5.9–Fig 5.16.
[260] For the observer locations see Chapter 2, section 2.5.1, Fig 2.1 and for the azimuths see section 2.6.3, Fig 2.5 and Table 2.4.

area, to produce an increase in the proportion of total visible area occupied by these viewsheds, compared to the analysis with azimuths.

In the case OB3, the angle excluded by the azimuths was small because cairn III is a round cairn and therefore excludes less of the view from an observer to its east, than a cairn with a flat face. But at OB8 the 69.03° excluded angle was small because the observer point was placed further from the cairn than the observer points at other flat-faced cairns. This was done to allow for the slight differences between the position of the cairn according to the 2012 survey and according to Engelbach's plan. The difference in the location of the cairn face is probably largely the result of errors in the georeferencing of Engelbach's plan, since the face of the cairn as surveyed in 2012 and the face of the cairn depicted by Engelbach should be in roughly the same place.[261]

Although the difference in cairn position was not resolvable with the available evidence, it emphasises how the precise positioning of an observer point relative to the face of the cairns can influence the resulting viewshed. In real terms, this mirrors how visibility and the experience of a view changes as a person moves through a landscape. In this case, an individual approaching the flat face of a cairn to undertake activities in the court would experience a decreasing viewshed as they got closer to the cairn. Even if they were tall enough to see over the top of the cairn, its bulk would obscure part of the view and would distract their attention. It is likely that this diminishing view would focus the attention of the person upon the immediate surroundings of the court and, if they turned around, the vista to the east.

5.2.3. Conclusion

The visibility analysis without azimuths was intended to assess how far they affected the results and whether the conclusions of the visibility analysis of the courts remained true when undertaken without azimuths. Overall most of the conclusions were consistent whether or not azimuths were used. The courts were generally more visible to the landscape than they had views of it. Courts I-V on Stelae Ridge south had much larger viewsheds than those on Stelae Ridge north, confirming that they had better views of the landscape and were much more visible to it. The visibility analysis without azimuths also confirmed that courts VI-VIII had more variable viewsheds than courts I-V and that court VII had the smallest projective and reflective viewsheds.

---

[261] For the georeferencing of Engelbach's sketch plan and the problems associated with it see Chapter 3, section 3.9.1.

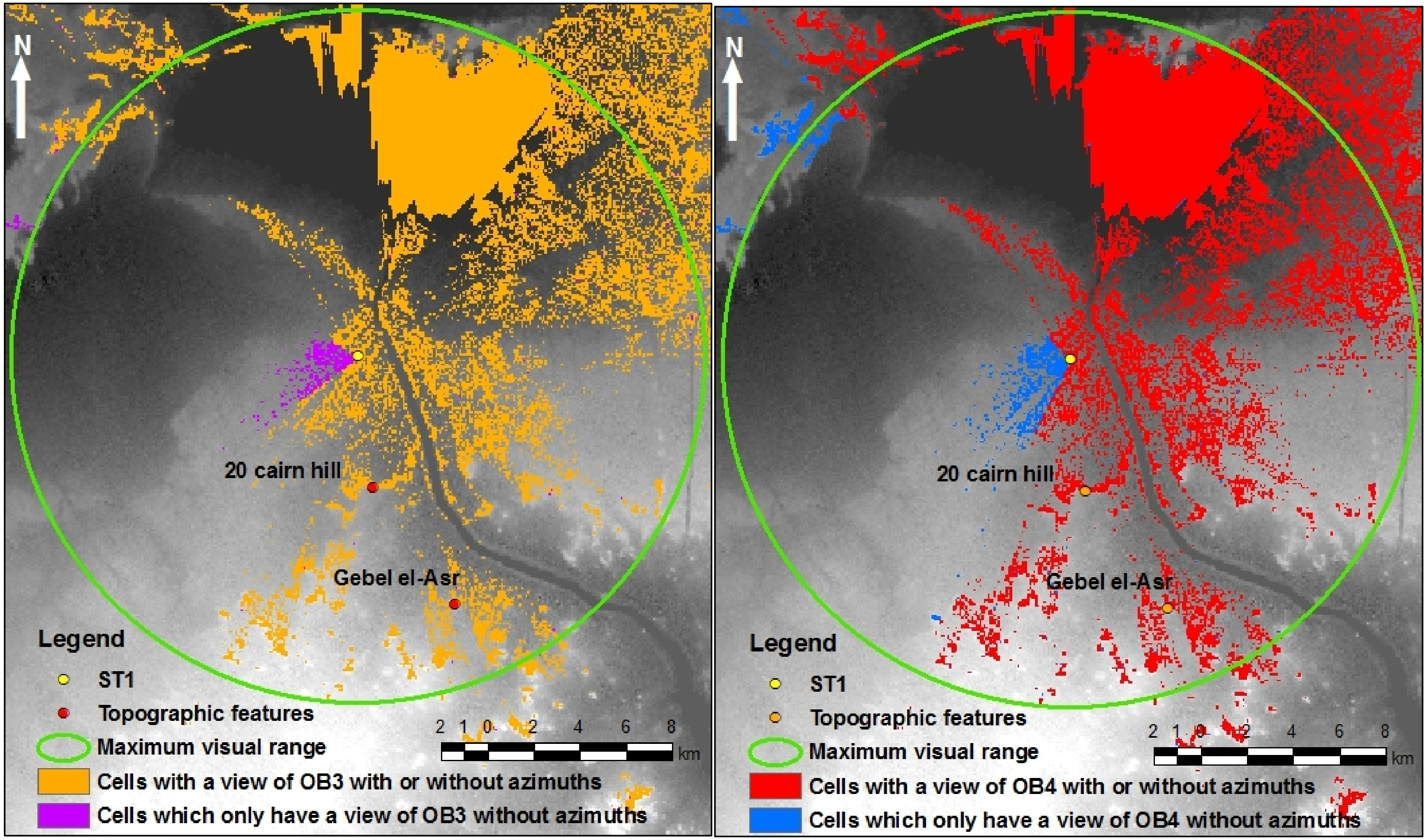


Fig 5.37: Comparison of the areas excluded from the reflective inclusive viewsheds by the azimuths at a) OB3, east of cairn III (left) and b) OB4, in court IV (right). The purple area excluded from the reflective viewshed of OB3 is much smaller than the blue area excluded from the reflective viewshed of OB4. Viewsheds shown overlying SRTM tilen22_e031_3arc_v2 (SRTM from the USGS).

There were some differences between the results of the visibility analysis with and without azimuths. The total visible area and the cumulative viewsheds for five or more courts generally increased in size as the azimuths were removed and an additional section of the landscape was included. Variation between the viewsheds of courts I-V on Stelae Ridge south was reduced when the azimuths were removed and this was matched by a reduction in the size of cumulative viewsheds for up to four courts and in the size of the exclusive viewsheds for most courts. Visually these trends were represented by a reduction in the south-west to north-east alignments in the area to the south-west of Stelae Ridge. Removing the azimuths made this area visible to much larger numbers of courts and increased consistency between the viewsheds for courts I-V on Stelae Ridge south. The changes in viewshed size also affected the ranking of the five courts on Stelae Ridge south, which had such similar viewsheds their size-order was highly susceptible to slight changes. Because of this, any ranking of courts I-V based on the sizes of viewsheds created with azimuths should be treated with caution.

In general the visibility analysis with azimuths probably overestimated the area excluded by the cairns, creating the alignments in the viewsheds, increasing variation between them, increasing the sizes of viewsheds visible to fewer courts and altering the relative ranking of courts I-V. Nonetheless the cairns would have had some effect upon visibility, so reality probably lies between the visibility analysis with and the visibility analysis without azimuths. Overall the visibility analysis of the courts without azimuths was a valuable exercise. It revealed the effects that the azimuths could have and provided a useful control against which the visibility analysis with azimuths can be compared.

5.3. Visibility of the cairns

Visibility analysis of the courts revealed differences between the visibility of the courts and the views from them. In particular the very good visibility of the courts on the southern ridge, compared to those on the northern, may be significant for interpretation and could be associated with either date or function. The visibility analysis without azimuths also suggested a possible relationship between the view of Stelae Ridge from the area to the north-west and the concentration of mining and other activities in this area.

As higher structures, the adjacent cairns would have been much more visible in the landscape than the courts, particularly when viewed against the sky. A reflective visibility analysis of the cairns was therefore undertaken, following the methods described in Chapter 2 section 2.4, the observer locations presented in section 2.5.2 and Fig 2.2, and the parameters detailed in section 2.6–2.7. It is not certain if the cairns could be or were used for observation, but there is no evidence of this, so no projective analysis will be undertaken at this stage.

Viewsheds generated from the visibility analysis of the cairns will be most comparable to the reflective visibility analysis of the courts without azimuths, although conclusions drawn from this comparison will probably also be applicable to the visibility analysis with azimuths, because almost all the patterns exhibited by the viewshed data were consistent whether or not the azimuths were present.

5.3.1. Cumulative viewshed analysis of the cairns

The primary difference between the reflective cumulative viewshed analysis of the cairns and that of the courts, was the change in target location from the area of the courts to the cairns and the increase in target height from 0m to 1.28m, representing the height of the cairns above ground level.The results of the reflective cumulative viewshed analysis of the cairns are shown in Fig 5.38 and quantified in Table 5.12 and Chart 5.3.

Table 5.12: Area of the reflective cumulative viewshed, broken down by how many cairns are visible from each raster cell.

Number of cairns visible	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)	
1	372	2.78	1.43
2	269	2.01	1.03
3	271	2.03	1.04
4	325	2.43	1.25
5	1613	12.06	6.20
6	3205	23.96	12.31
7	4150	31.02	15.94
8	15832	118.35	60.81
Any (TVA)	26037	194.64	100
<5	1237	9.25	4.75
>=6	23187	173.33	89.05
>=5	24800	185.39	95.25

The reflective cumulative viewshed analysis of the cairns has some similarities with the projective cumulative viewshed analysis of the courts, both with and without azimuths.[262] These include the appearance of the viewshed, the small area with visibility of less than five cairns and the pattern of increasing viewshed area with the number of cairns visible.

[262] For the cumulative viewshed analysis of the courts with azimuths see section 5.1.1, Table 5.1, Chart 5.1 and Fig 5.1–Fig 5.2. For the cumulative viewshed analysis of the courts without azimuths see section 5.2.1, Table 5.2, Chart 5.2 and Fig 5.23 – Fig 5.24.

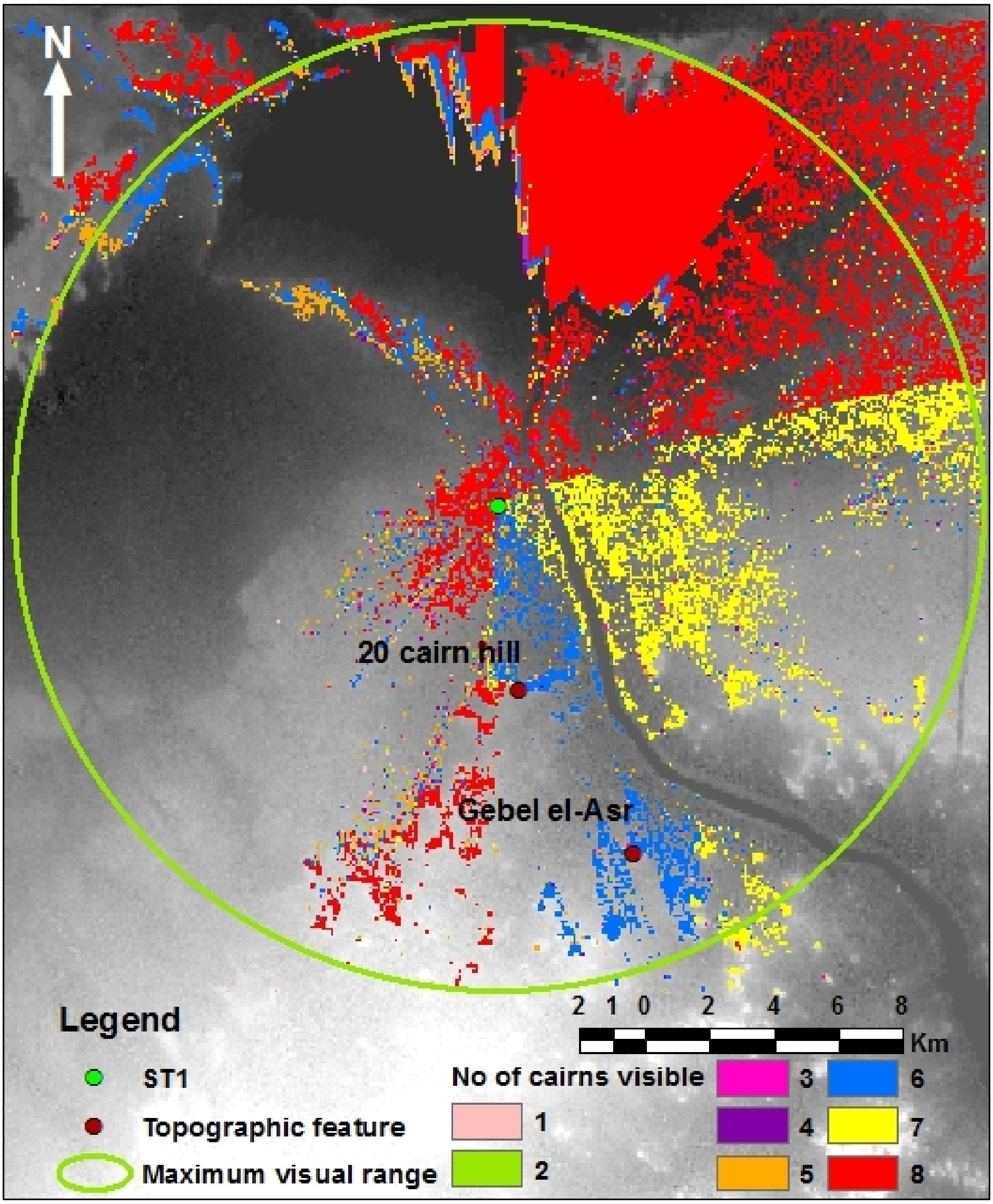
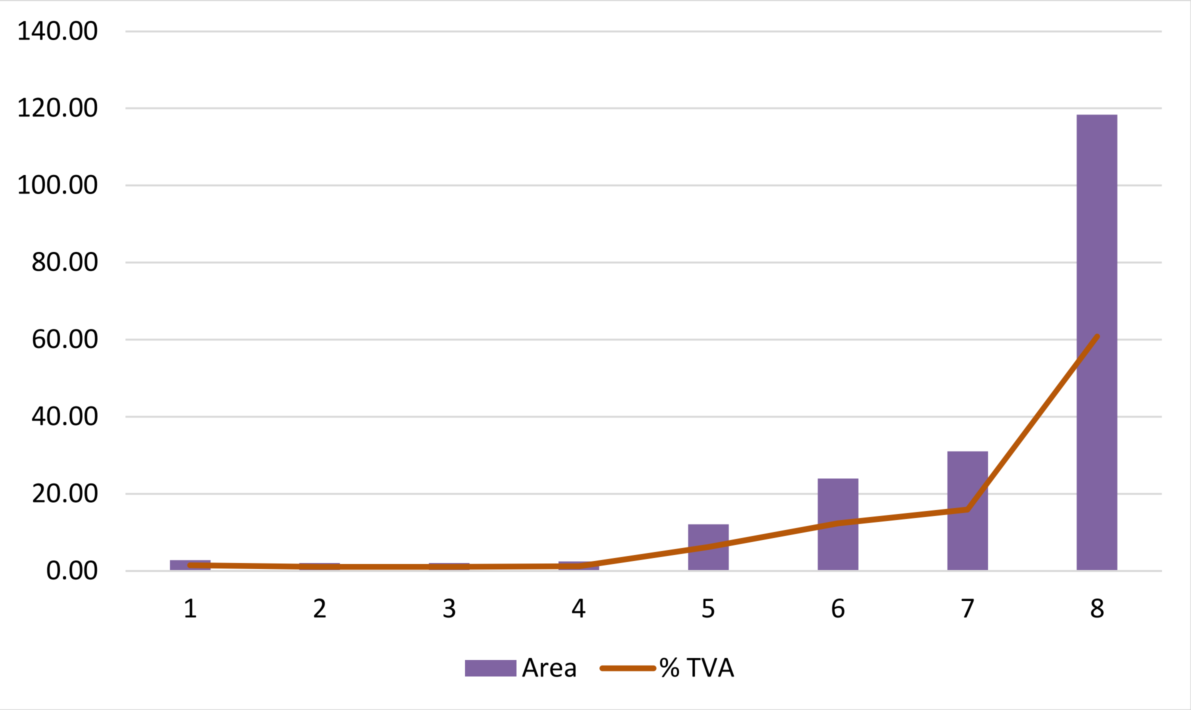


Fig 5.38: Cumulative viewshed showing from where the Stelae Ridge cairns could be seen and how many cairns could be seen. Note that the cumulative viewshed does not indicate which cairns can be seen, merely the total number visible from each raster cell. Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

However, the cumulative viewsheds of the cairns are larger than the projective cumulative viewsheds of the courts, with or without azimuths. The total visible area and area where eight cairns were visible are also larger than the total visible area of the courts and the area where eight courts were visible.

Chart 5.3. The areas of the reflective cumulative viewsheds by number of cairns visible. Bars show area in km^2 and lines show percentage of the total visible area (Data taken from Table 5.12).



The cairns have larger cumulative viewsheds than the courts because of their greater target height, which naturally makes each cairn visible from a larger area. This also explains why six cairns were visible from 20 cairn hill and the Gebel el-Asr, when the reflective cumulative viewshed analysis of the courts indicated that only five courts would be visible from those two locations.

5.3.2. Observer points analysis of the cairns

To obtain more information about the visibility of the different ridges and individual cairns, reflective observer points analysis of the cairns was undertaken. Viewsheds for individual cairns and all the cairns on each ridge were extracted from it. Exclusive viewsheds for each cairn and viewsheds for all cairns from the same reign, with the same court structure or artefacts were not extracted from the observer points analysis of the cairns because the visibility analysis of the courts had already revealed that this would not provide any additional information.[263]

Stelae Ridge north and Stelae Ridge south

In section 5.1.2 and 5.2.2 viewsheds for all the courts on each ridge revealed differences between Stelae Ridge north and Stelae Ridge south and indicated that Stelae Ridge south had a better view and was much more visible than Stelae Ridge north. The analysis of the courts without azimuths also suggested a possible relationship between the mining area to the west of Stelae Ridge, and a good view of the cairns on Stelae Ridge north. Viewsheds for all cairns on each ridge were therefore extracted from the reflective observer points analysis to determine if the patterns visible in the observer points analysis of the courts held true for the cairns as well.

Fig 5.39 shows the inclusive and exclusive reflective viewsheds for Stelae Ridge north and Stelae Ridge south. The sizes of these viewsheds are quantified in Table 5.13.

Table 5.13: Areas of exclusive and inclusive reflective viewsheds where all the cairns on each ridge were visible.

Ridge	Cairns	Raster cells		Proportion of total visible area (%)
		Number	Area (km^2)	
North Exclusive	VI, VII and VIII	7	0.05	0.03
North Inclusive		15959	119.30	61.29
South Exclusive	I-V	1498	11.20	5.75
South Inclusive		24573	183.69	94.38

The reflective viewsheds for all the cairns on each ridge are quite similar to the viewsheds of the courts without azimuths, but the viewsheds of the cairns are much larger because both the observer and the target height are above ground level. The increase in target height is also responsible for the smaller exclusive viewshed of the cairns on Stelae Ridge south, compared to the equivalent viewshed extracted from the reflective observer points analysis of the courts without azimuths (Table 5.10). Increasing the target height makes each cairn more visible and as all the cairns become more visible the exclusive viewsheds are reduced in size.

---

[263] Section 5.1.2 and 5.2.2 describe how the exclusive viewsheds for each court revealed nothing except the impact of the azimuths. Viewsheds for all the courts with the same artefacts, dating to the same reign or with the same type of structure were extracted in section 5.2.1, but revealed no relationship between these aspects of the courts and their visibilities.

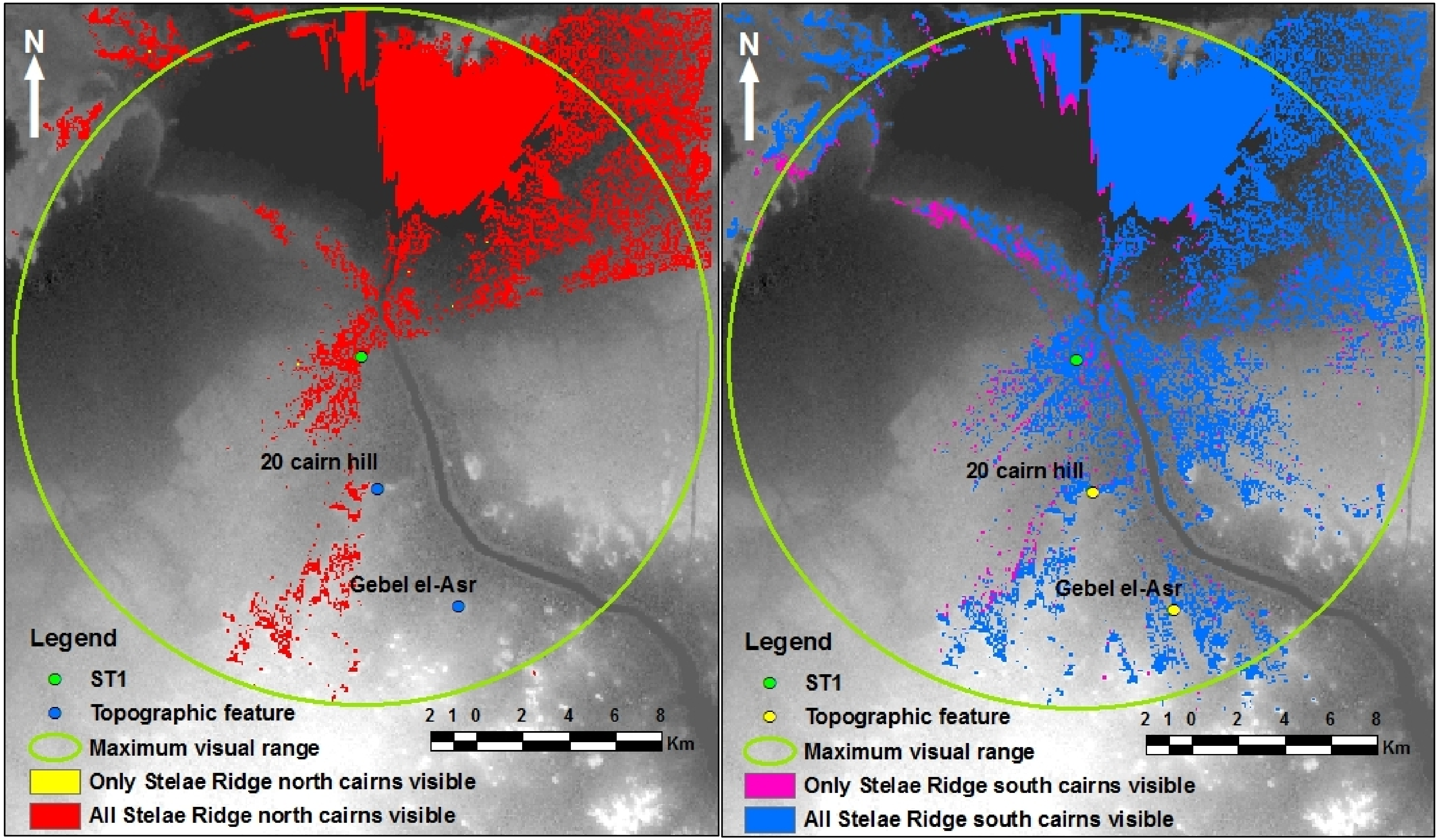


Fig 5.39: a) Inclusive (red and yellow) and exclusive (yellow only) reflective viewsheds for all cairns on Stelae Ridge north (left) and b) Inclusive (blue and pink) and exclusive (pink only) reflective viewshed for all cairns on Stelae Ridge south (right). Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

The reflective viewsheds for all cairns on each ridge exhibit the same pattern as the viewsheds for the courts without azimuths. Specifically, the cairns on Stelae Ridge south are visible from a much larger area than those on Stelae Ridge north, including a large area 11.20km^2 that did not have a view of the cairns on Stelae Ridge north. It is clear that the southern ridge provided the best vantage point for cairns used as markers or reference points in the landscape. Not only were they visible from a much larger area of the landscape, they were visible from a significant area where the northern cairns were obscured, including 20 cairn hill, the Gebel el-Asr and significant areas to the south and south-east, which did not have a view of all the cairns on Stelae Ridge north.

While all the cairns on the southern ridge were highly visible to the south and south-east, Fig 5.39a shows that all the cairns on the northern ridge were highly visible to the north and west. This would have made them visible from the main focus of the mining activities in the area north-west and west of Stelae Ridge. They may have acted as markers for those moving from the mining area towards Stelae Ridge, either for activities on it or to continue south to 20 cairn Hill and either the Gebel el-Asr gneiss quarries or the track to the Nile.

Viewsheds of each cairn

Viewsheds showing where each cairn was visible were extracted from the observer points analysis and are presented in Fig 5.40–Fig 5.47. The areas of the viewsheds are quantified in Table 5.14.

Table 5.14: Areas of inclusive reflective viewsheds for each cairn.

Observer point	Cairn	Raster cells		Proportion of total visible area (%)
		Number	Area (km^2)	
COB1	I	25217	188.51	96.85
COB2	II	25143	187.95	96.57
COB3	III	25229	188.60	96.90
COB4	IV	25250	188.75	96.98
COB5	V	25323	189.30	97.26
COB6	VI	23538	175.96	90.40
COB7	VII	16131	120.59	61.95
COB8	VII	20193	150.95	77.56
Any (TVA)	All	26037	194.64	100

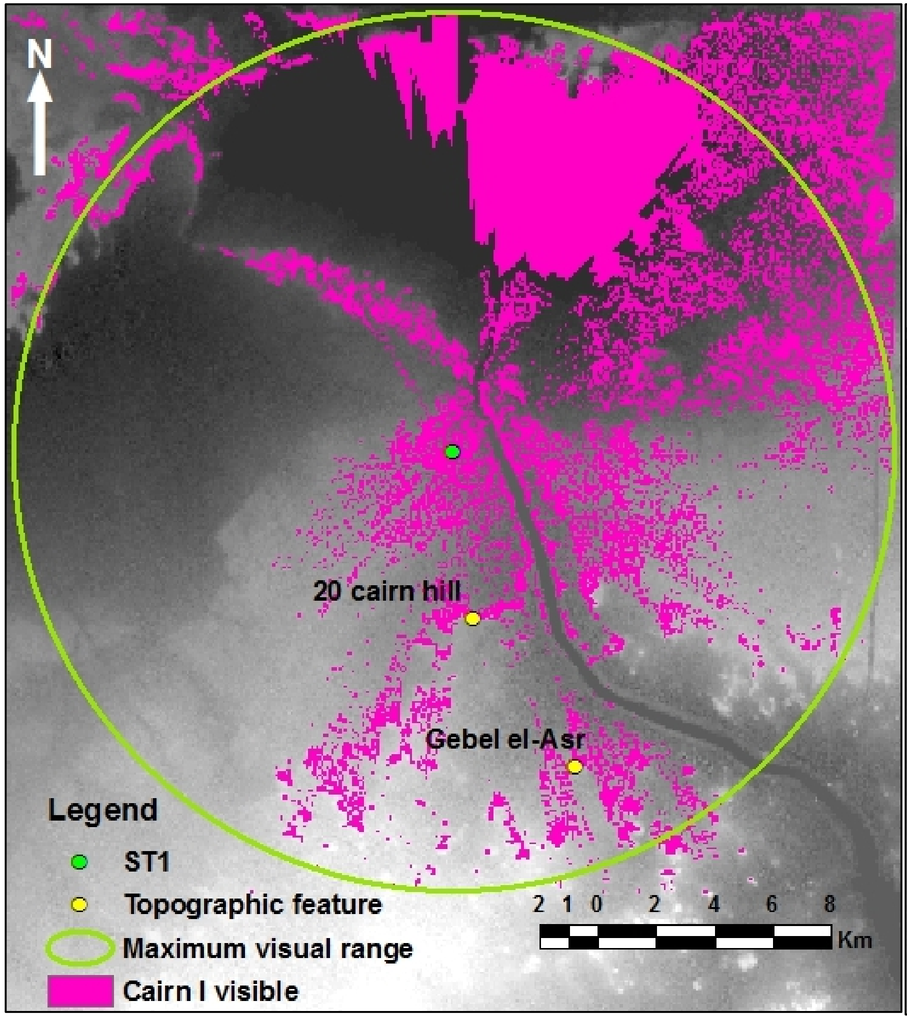


Fig 5.40: Inclusive reflective viewshed showing in pink where cairn I would be visible.

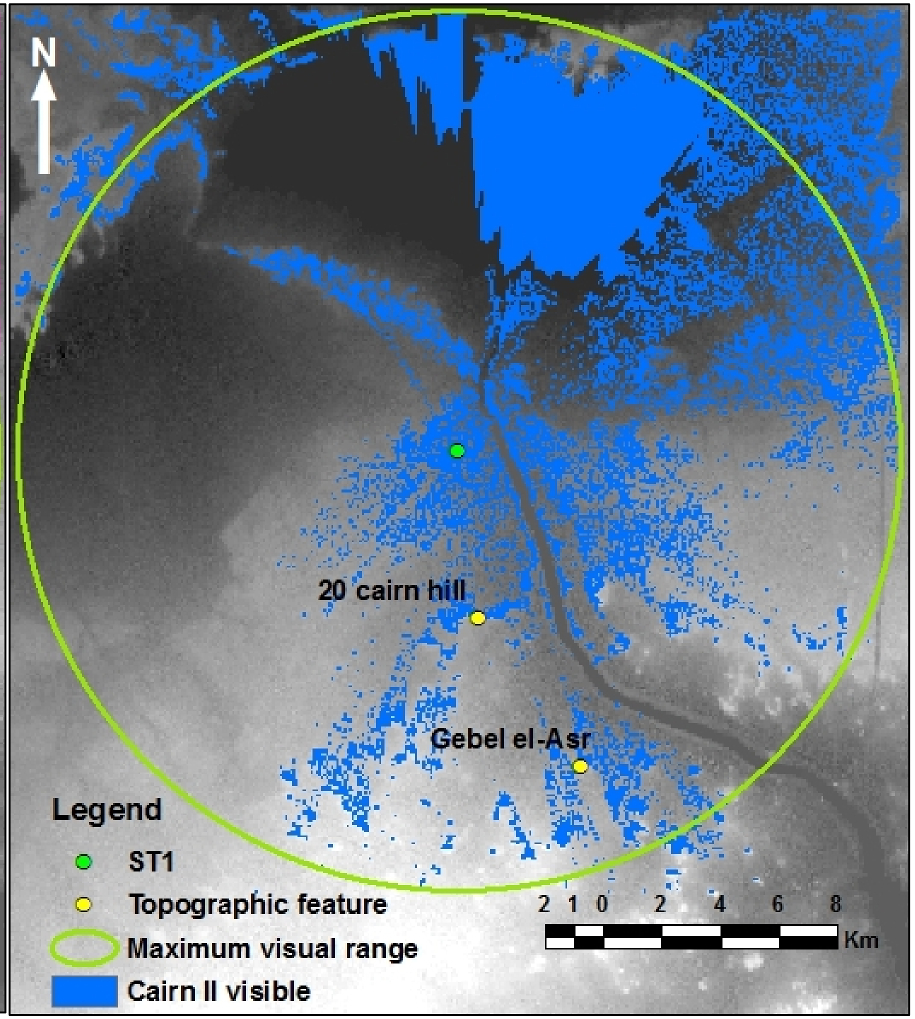


Fig 5.41: Inclusive reflective viewshed showing in blue where cairn II would be visible

Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

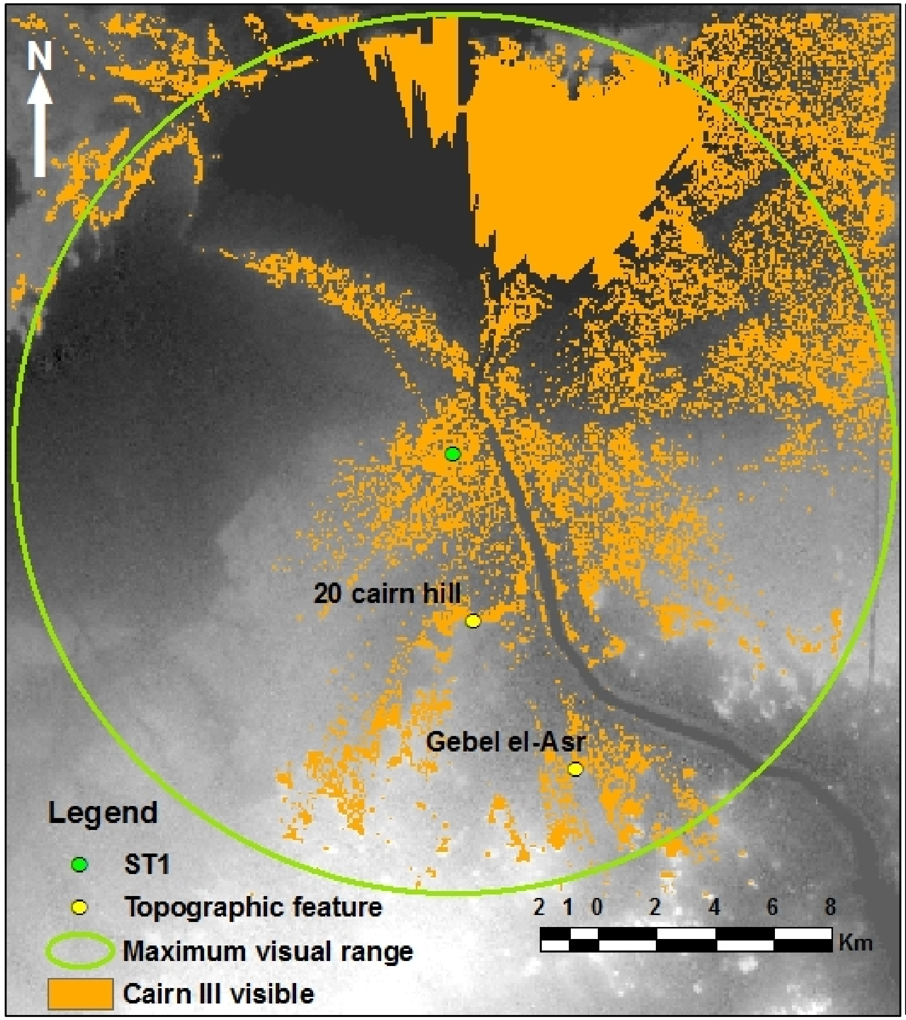


Fig 5.42: Inclusive reflective viewshed showing in orange where cairn III would be visible.

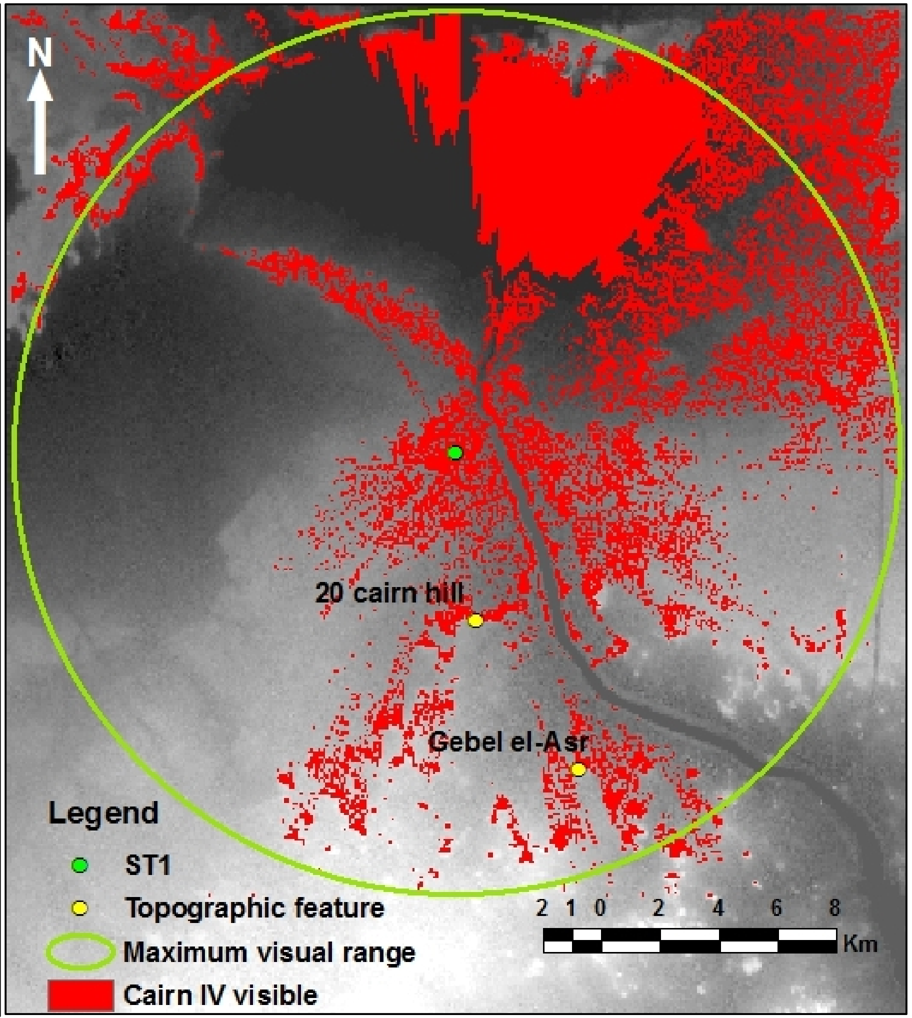


Fig 5.43: Inclusive reflective viewshed showing in red where cairn IV would be visible

Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

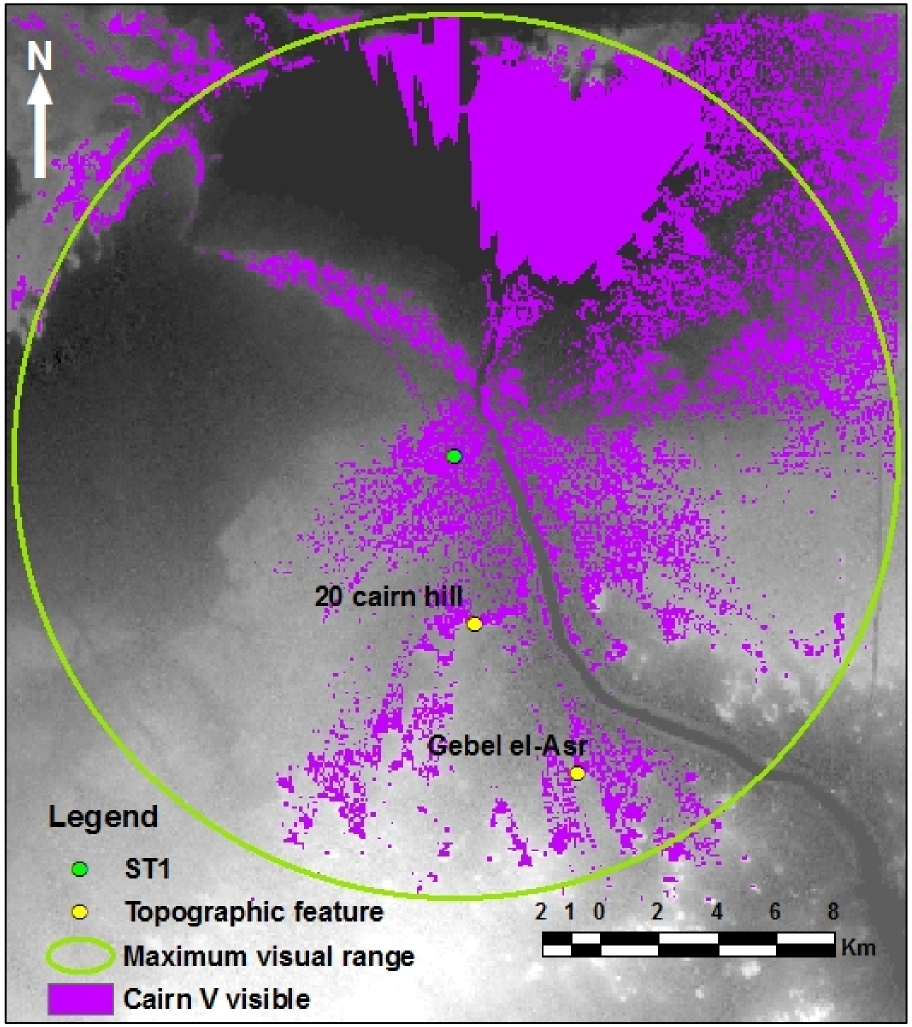


Fig 5.44: Inclusive reflective viewshed showing in purple where cairn V would be visible.

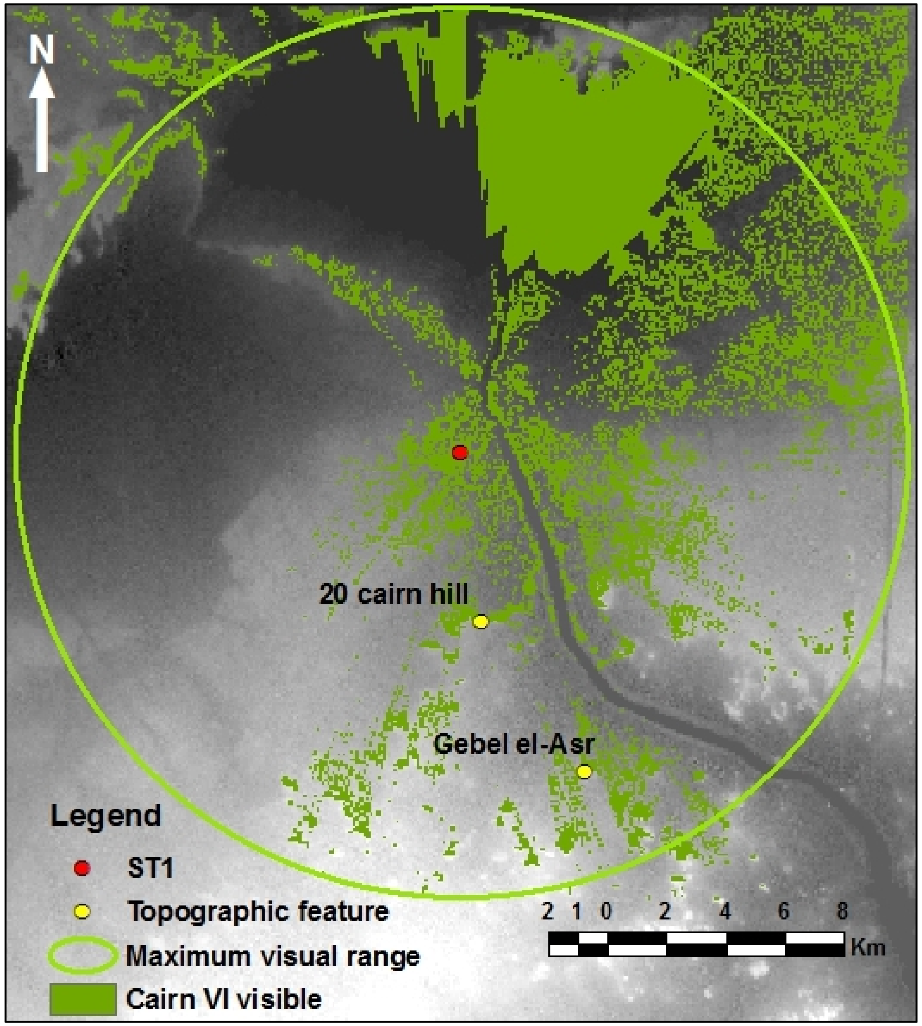


Fig 5.45: Inclusive reflective viewshed showing in green where cairn VI would be visible

Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

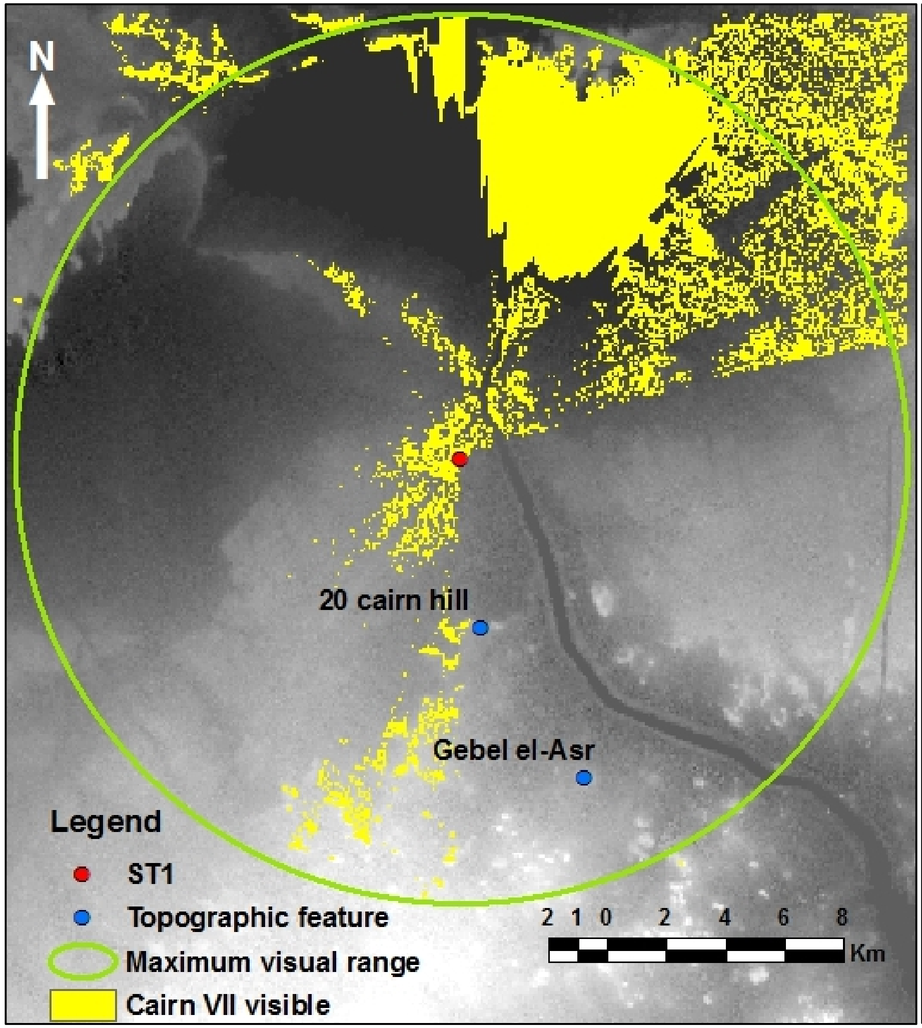


Fig 5.46: Inclusive reflective viewshed showing in yellow where cairn VII would be visible.

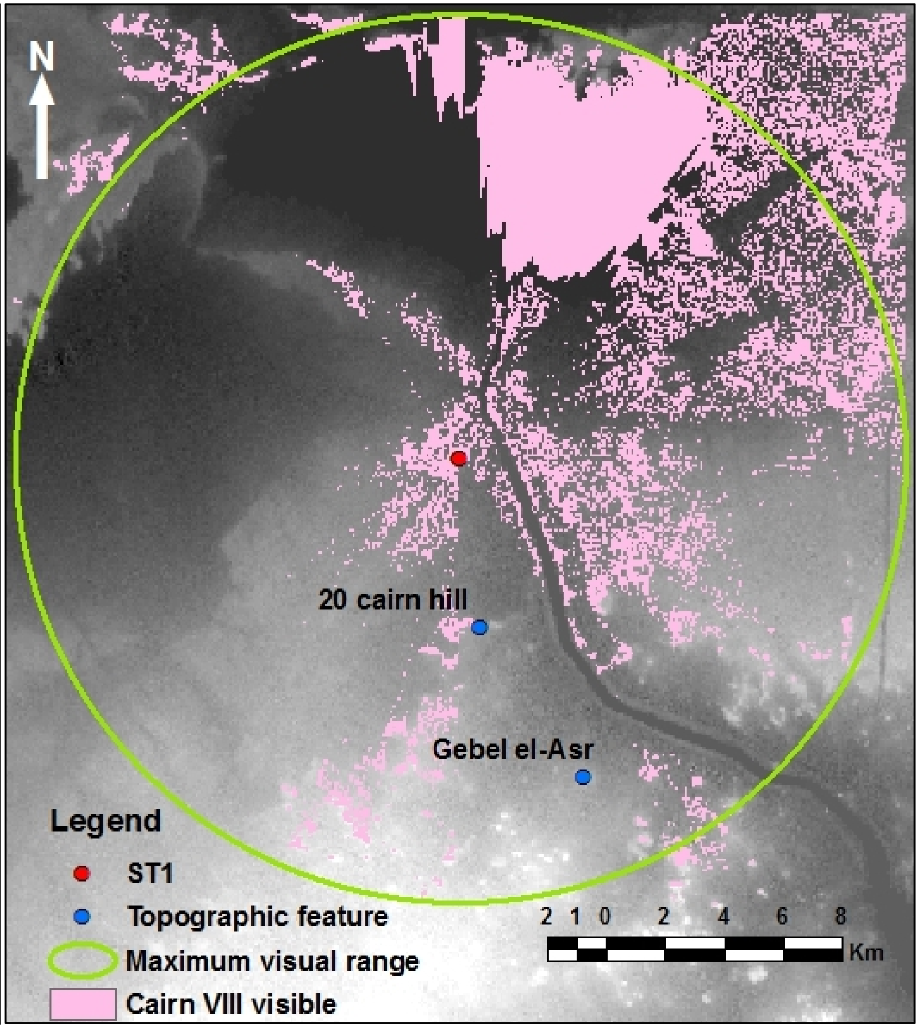


Fig 5.47: Inclusive reflective viewshed showing in pink where cairn VIII would be visible

Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

The reflective viewsheds for each cairn appear quite similar to the projective viewsheds for each court extracted from the observer points analysis without azimuths (Table 5.11), although the viewsheds for the cairns are significantly larger than either the projective or reflective viewsheds for the courts because of their higher target height. The reflective viewsheds of cairns I-V on Stelae Ridge south are large and very consistent with each other, while the viewsheds of cairns VI-VIII on Stelae Ridge north are smaller and more varied in size and appearance. Cairn VII has the smallest viewshed, then cairn VIII, while cairn VI has the largest viewshed of all cairns on Stelae Ridge north. As with the projective viewsheds for the courts the viewshed for cairn VI is closer in size and appearance to the viewsheds for cairns I-V and, unlike the other two cairns on the northern ridge, it is visible from 20 cairn hill and the Gebel el-Asr.

The higher target height of the cairns altered the sizes of the viewsheds of cairns I-V on the southern ridge and, because the structures on the southern ridge have very similarly sized viewsheds, this resulted in a different ordering of cairns I-V from largest to smallest, compared to the visibility analysis of the courts:[264] Cairn V has the largest viewshed, followed by cairn IV, cairn III, cairn I and then cairn II, which has the smallest viewshed. There is only 1.35km^2 difference in size between the largest and the smallest viewshed so all the cairns would have been highly visible, but the slight differences in viewshed size may reflect the impact of more or less central positions along the crest of the ridge.

While cairns VII and VIII on Stelae Ridge north are not particularly visible from the south and are not at all visible from 20 cairn hill or the Gebel el-Asr, they are highly visible from the north and west of Stelae Ridge. This is the area where most of the mining activity took place and the northern cairns are the closest to it. While space on the southern ridge may have been a factor in locating these cairns on the northern ridge, their proximity to the mining area may also have influenced their location or provided collateral benefits.

5.3.3. Conclusion

The reflective visibility analysis of the cairns was intended to reveal how their higher target height would affect their visibility within the landscape. In general the cumulative and individual viewsheds of the cairns were larger than the viewsheds of the courts, either with or without azimuths. The higher target height also produced a different ranking by viewshed size for the cairns on Stelae Ridge south. The actual differences between their viewsheds were very small, although they probably reflect the different positions of the structures on the

---

[264] A similar effect was observed in section 5.2.2 in the visibility analysis of the courts without azimuths.

ridge and may therefore relate indirectly to decisions about cairn location and the order in which the cairns were constructed.

Otherwise many of the conclusions drawn from the visibility analysis of the courts were confirmed by the reflective visibility analysis of the cairns. Cairns I-V on the southern ridge were much more visible than cairns VI-VIII, and particularly cairns VII and VIII. Cairns I-V were also visible from a large area to the south, where the Gebel el-Asr gneiss quarries and the ancient track to the Nile were located, and together with cairn VI, were visible from both 20 cairn hill and the Gebel el-Asr. Therefore these cairns would have made a valuable marker for individuals approaching from the south, including along the track via 20 cairn hill.

While cairns VII and VIII on Stelae Ridge north are not particularly visible from the south or south-east, and cairn VII has the smallest viewshed of all the cairns, they are quite visible from the north and north-west where many of the mines were located. These cairns may have acted as markers for people moving across the landscape from the mining area, either to Stelae Ridge or via Stelae Ridge to destinations further south, including the gneiss quarries and the track to the Nile.

5.4. Testing the parameters for visibility analysis of the cairns

The visibility analysis of the cairns involved two parameters which differentiated them from the visibility analysis of the courts; observer location and the height of the target. Additional visibility analysis was undertaken to assess the impacts of these parameters upon the results of the visibility analysis and provide data for comparison with the visibility analysis of the courts.

Where relevant the sizes of the viewsheds created during this process are presented in the following tables alongside data from the equivalent original viewshed. The numbers in the tables have been coloured to indicate whether the results of the tests are lower or higher than the originals. Blue numbers indicate a lower figure and red numbers indicate a higher figure in the test viewsheds.

5.4.1. The effect of changes in observer location

There is a slight difference in location between the visibility analysis of the courts and the cairns. To assess the effect of the different observer locations and enable comparisons to be made with the reflective cumulative viewshed analysis of the courts, the visibility analysis of the cairns was repeated using the same locations and a target height of 0m, representing ground level beneath the cairns.

Cumulative viewshed analysis

The results of the cumulative viewshed analysis of ground level at the cairns is presented in Fig 5.48 and Table 5.15. It revealed that the slight difference in location between the cairns and the courts had minimal effect upon the reflective cumulative viewsheds. This is not surprising because the slight shift in observer location has no impact upon the height above sea level at the target because of the low resolution of the SRTM. If it had been possible to undertake topographic survey of the area around Stelae Ridge and create a hybrid DTM, the more detailed model of the landscape might have revealed significant differences or provided reassurance that ground level was genuinely the same at the courts and beneath the cairns.

Table 5.15: Comparison of the reflective cumulative viewsheds of the courts (left) and the cairns (right). Both were calculated without azimuths and the target height was 0m.

Number visible	Courts			Cairns		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)		Number	Area (km^2)	
1	396	2.96	1.69	380	2.84	1.62
2	248	1.85	1.06	275	2.06	1.17
3	313	2.34	1.34	335	2.50	1.43
4	414	3.09	1.77	427	3.19	1.82
5	7581	56.67	32.34	7485	55.95	31.94
6	6625	49.52	28.26	5753	43.01	24.55
7	3893	29.10	16.61	3752	28.05	16.01
8	3973	29.70	16.95	5024	37.56	21.44
Any (TVA)	23443	175.25	100.00	23431	175.16	100
<5	1371	10.25	5.85	1417	10.59	6.05
>=6	14491	108.33	61.81	14529	108.61	62.01
>=5	22072	165.00	94.15	22014	164.56	93.95

There are some slight differences in the sizes of the reflective cumulative viewsheds for ground level at the courts and the cairns, but overall they are very similar. It is significant that ground level at all eight cairns is visible from 7.86km^2 more than ground level at all eight courts, perhaps implying that the cairns were constructed in a slightly more visible location. This would be consistent with their apparent position in Engelbach's sketch plan in Chapter 3, section 3.2.1, Fig 3.1, which appears to show the cairns in a slightly more visible position along the crests of the ridges and the courts slightly off the crests to the east.

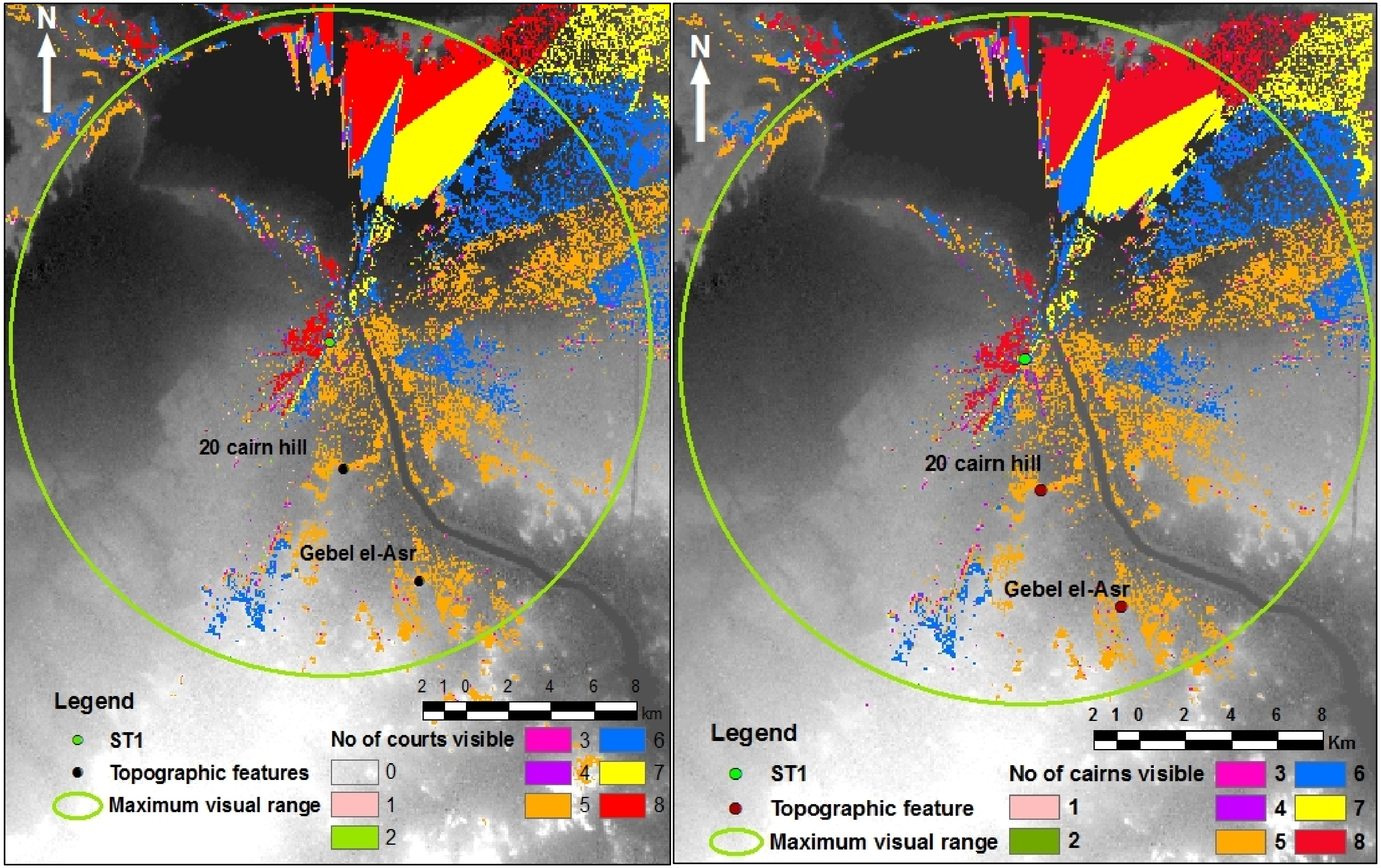


Fig 5.48: Comparison of the reflective cumulative viewsheds without azimuths showing where ground level at a) the courts (left) and b) the cairns (right) was visible. Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

Observer points analysis

Previous visibility analysis had revealed significant differences between the visibility of the individual courts and cairns and between the two groups on the different ridges. The viewsheds of the structures on Stelae Ridge south were found to be very sensitive to changes in parameters, such as the presence of azimuths or increased target height. Reflective observer points analysis of ground level beneath the cairns was undertaken to determine how a change in location affected the results of the visibility analysis.

Stelae Ridge north and Stelae Ridge south

The visibility analysis of the courts and of the cairns concluded that there were significant differences between the different ridges. Visibility of structures on Stelae Ridge south was found to be much better than those on Stelae Ridge north, particularly where the area to the south was concerned, although Stelae Ridge north was visible from the core mining area to the north and west. To determine if these patterns were also consistent for ground level beneath the cairns, reflective viewsheds for ground level beneath all the cairns on each ridge were extracted from the observer points analysis and are shown in Fig 5.49. Table 5.16 compares the sizes of these viewsheds to those of the courts without azimuths.

Table 5.16: Comparison of the inclusive and exclusive reflective viewsheds for ground level in all the courts on each ridge (left) and beneath all the cairns on each ridge (right). Both were calculated without azimuths and the target height was 0m.

		Courts (no azimuths)			Cairns		
		Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
Ridge	Structures	Number	Area (km^2)		Number	Area (km^2)	
North Exclusive	VI, VII and VIII	4	0.03	0.02	3	0.02	0.01
North Inclusive		4014	30.01	17.12	5247	39.22	22.39
South Exclusive	I-V	7512	56.16	32.04	7419	55.46	31.66
South Inclusive		21967	164.21	93.70	21909	163.78	93.50

Table 5.16 shows that except for the inclusive viewshed for Stelae Ridge north, the viewsheds are virtually the same size whether the targets were ground level at the courts or the cairns. Although the viewsheds for ground level at the cairns are marginally smaller, the difference is less than $1km^2$.

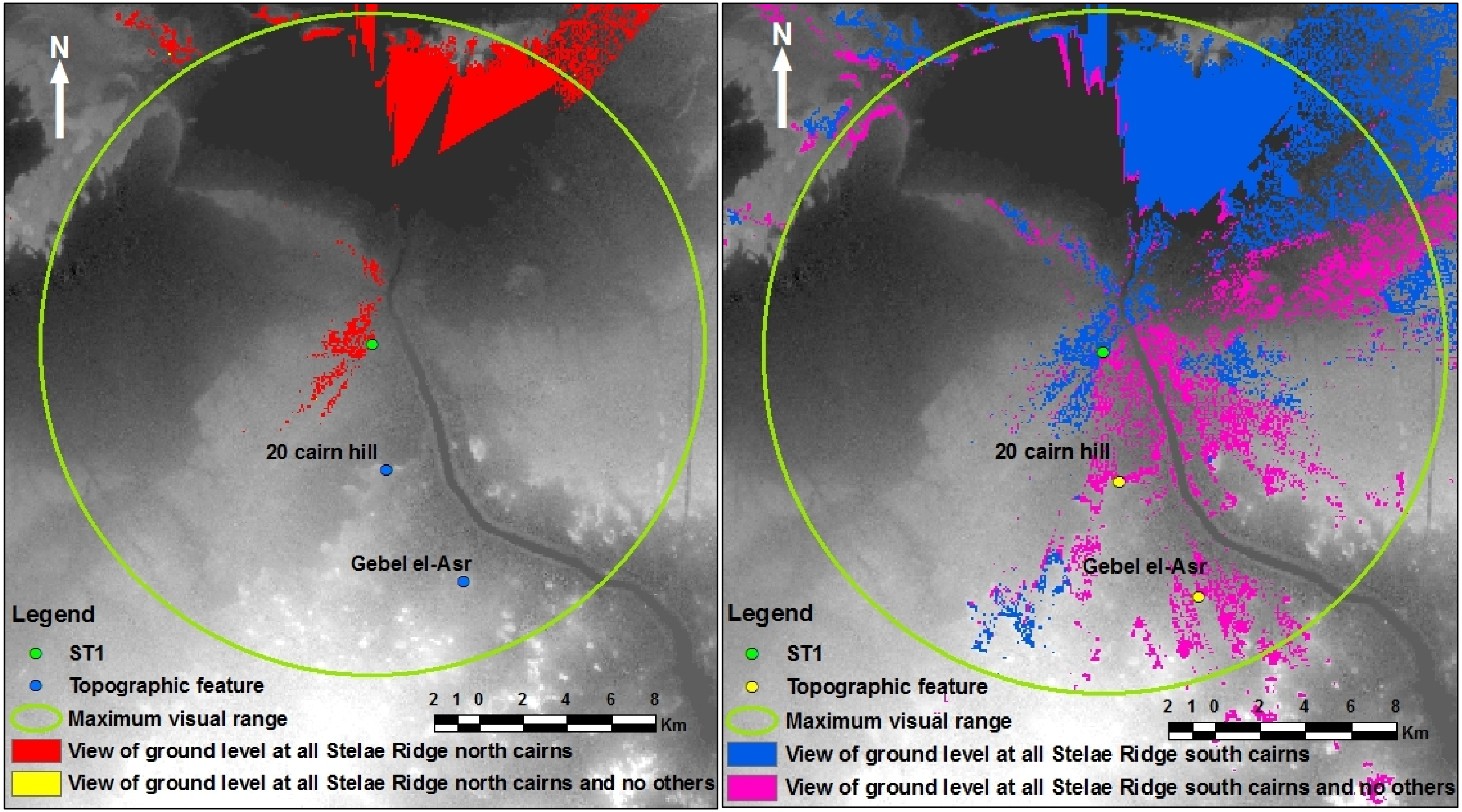


Fig 5.49: a) Inclusive (red and yellow) and exclusive (yellow only) reflective viewsheds for ground level at all cairns on Stelae Ridge north (left) and b) Inclusive (blue and pink) and exclusive (pink only) reflective viewsheds for ground level at all cairns on Stelae Ridge south (right). Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

The pattern of visibility is also the same for ground level at the cairns as it was for ground level at the courts. Stelae Ridge south has larger viewsheds, indicating that ground level at it was more visible than at Stelae Ridge north. Furthermore the large exclusive viewshed for Stelae Ridge south reveals it was also visible from quite a large area, including 20 cairn hill and the Gebel el-Asr, that did not have a view of ground level at all the Stelae Ridge north cairns. A key component of the viewshed for ground level at all the Stelae Ridge north cairns is the area to the north and west, where the core of the mining zone was located.

The inclusive viewshed for ground level at the Stelae Ridge north cairns is slightly larger than the equivalent viewshed for the courts. This may reflect genuine differences between the visibility of ground level at the cairns and courts, relating to their relative positions on the ridge. During the visit to the site in 2012, the cairns of the two surviving cairn-courts on Stelae Ridge north were observed on the crest of the ridge, while their respective courts were locate to the east and were slightly lower and therefore less visible.

Viewsheds for ground level at each cairn

To assess the differences between the reflective viewsheds for ground level at the courts and ground level at the cairns, individual viewsheds for ground level at each cairn were extracted from the observer points analysis. The sizes of those viewsheds are given in Table 5.17. Visually the viewsheds were almost identical to the reflective viewsheds for each court calculated without azimuths in section 5.2.2 and Fig 5.29–Fig 5.36.

Table 5.17: Comparison of the reflective viewsheds of ground level in the courts (left) and beneath the cairns (right). Both were calculated without azimuths and the target height was 0m.

	Courts (no azimuths)			Cairns		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
Cairn-court	Number	Area (km^2)		Number	Area (km^2)	
I	22712	169.78	96.88	22664	169.42	96.73
II	22595	168.91	96.38	22588	168.85	96.40
III	22681	169.55	96.75	22690	169.62	96.84
IV	22744	170.02	97.02	22692	169.63	96.85
V	22735	169.95	96.98	22692	169.63	96.85
VI	9108	68.09	38.85	9727	72.71	41.51
VII	5074	37.93	21.64	6531	48.82	27.87
VIII	12528	93.65	53.44	12458	93.13	53.17
Any (TVA)	23443	175.25	100	23431	175.16	100.00

The individual viewsheds for ground level at each cairn are consistent with the cumulative viewshed analysis, which revealed minimal differences between the visibility of ground level at the cairns and in the courts. The exceptions are cairns VI and VII whose much larger viewsheds are probably responsible for the larger reflective inclusive viewshed for ground level at the Stelae Ridge north cairns.

The individual viewsheds for ground level at the cairns also revealed a different order when ranked by viewshed size, compared to the visibility of the courts without azimuths or the cairns. Table 5.18 ranks the structures from 1 to 8 by reflective viewshed size for the courts, cairns and ground level beneath the cairns.

Table 5.18: Structures ranked by reflective viewshed size. (Data from Table 5.11, Table 5.14 and Table 5.17).

	Court (without azimuths)		Cairn		Ground level at cairn	
Cairn-court	Area (km^2)	Ranking	Area (km^2)	Ranking	Area (km^2)	Ranking
I	169.78	3	188.51	4	169.42	4
II	168.91	5	187.95	5	168.85	5
III	169.55	4	188.60	3	169.62	3
IV	170.02	1	188.75	2	169.63	1
V	169.95	2	189.30	1	169.63	1
VI	68.09	6	175.96	6	72.71	7
VII	37.93	8	120.59	8	48.82	8
VIII	93.65	7	150.95	7	93.13	6

The ranking of the Stelae Ridge structures based upon the size of their viewsheds is not consistent across the three visibility analyses. However, there are some general trends. In all cases cairn-court VII has the smallest viewshed, cairn-court II has the smallest viewshed on Stelae Ridge south and cairn-courts IV and V have the two largest viewsheds, with very little difference in size between them. Cairn-courts I and III are either 3 or 4 in the ranking, and cairn-courts VI and VIII are either 6 or 7. Overall, cairn-courts I-V on Stelae Ridge south have the largest viewsheds, which are also very similar in size to each other, while cairn-courts VI-VIII on Stelae Ridge north have the smallest viewsheds and are also quite variable in size.

While there is some variation in the precise sizes of the viewsheds and some corresponding differences in their size-order ranking, the reflective visibility analysis of ground level at the cairns generally supports the conclusions drawn elsewhere. It confirms that the structures on Stelae Ridge south were the most visible, and that they were much more visible than Stelae Ridge north, particularly from the south. Neither 20 cairn hill nor the Gebel el-Asr had views of ground level at any of the cairns on Stelae Ridge north, while a person at both topographic features would have been able to see ground level at all the structures on Stelae Ridge south. Stelae Ridge north would have been more visible from the north and west in the area of the mines. In terms of visibility of ground level at the ridge before the cairns were built, cairn-court VII had the smallest viewshed and was least visible, while cairn-courts IV and V had the largest viewsheds and were the most visible.[265]

5.4.2. The effect of different target heights upon visibility of the cairns

In the reflective visibility analysis of the cairns the same target height of 1.28m was used for every cairn to ensure consistency. However, the 2012 survey described in Chapter 3, section 3.7.2, indicates that the two best preserved cairns, cairn VII and cairn VIII were 1.19m and 1.36m high respectively. Cairn VI was 0.91m high, but as it had been damaged this is unlikely to represent its original height. The other cairns would potentially have been of different heights, but these are now unknowable. Changing the target heights of cairns VII and VIII would potentially change the visibility analysis, particularly in as far as it pertains to these cairns on the northern ridge. To test the effect of this the cumulative viewshed and observer points analysis were re-run using the surviving heights of 1.19m and 1.36m for cairns VII and VIII.

Cumulative viewshed analysis

A reflective cumulative viewshed was created using the revised cairn heights for cairns VII and VIIII and is shown in Fig 5.50 and presented in Table 5.19.[266] It shows that the revised target heights for cairns VII and VIII had minimal effect, although there were some small changes. The reflective cumulative viewshed created using the revised cairn heights is very similar to the original shown in Fig 5.38 and, overall, changing the target height of cairns VII and VIII made very little difference to the resulting cumulative viewshed.

---

[265] As is apparent from section 5.1.2, if the effect of the cairns upon visibility of the courts is taken into account with azimuths, courts IV and V no longer appear as visible. As section 5.2 demonstrated, while the azimuths probably overestimate the effect of the cairns upon visibility, they would have had some impact and reality probably lay between the results of the analysis with and without azimuths. Naturally this would not have had any effect upon the visibility of the cairns.
[266] A figure of 1.28m was used for the heights of cairns I–VI in the cumulative viewshed analysis.

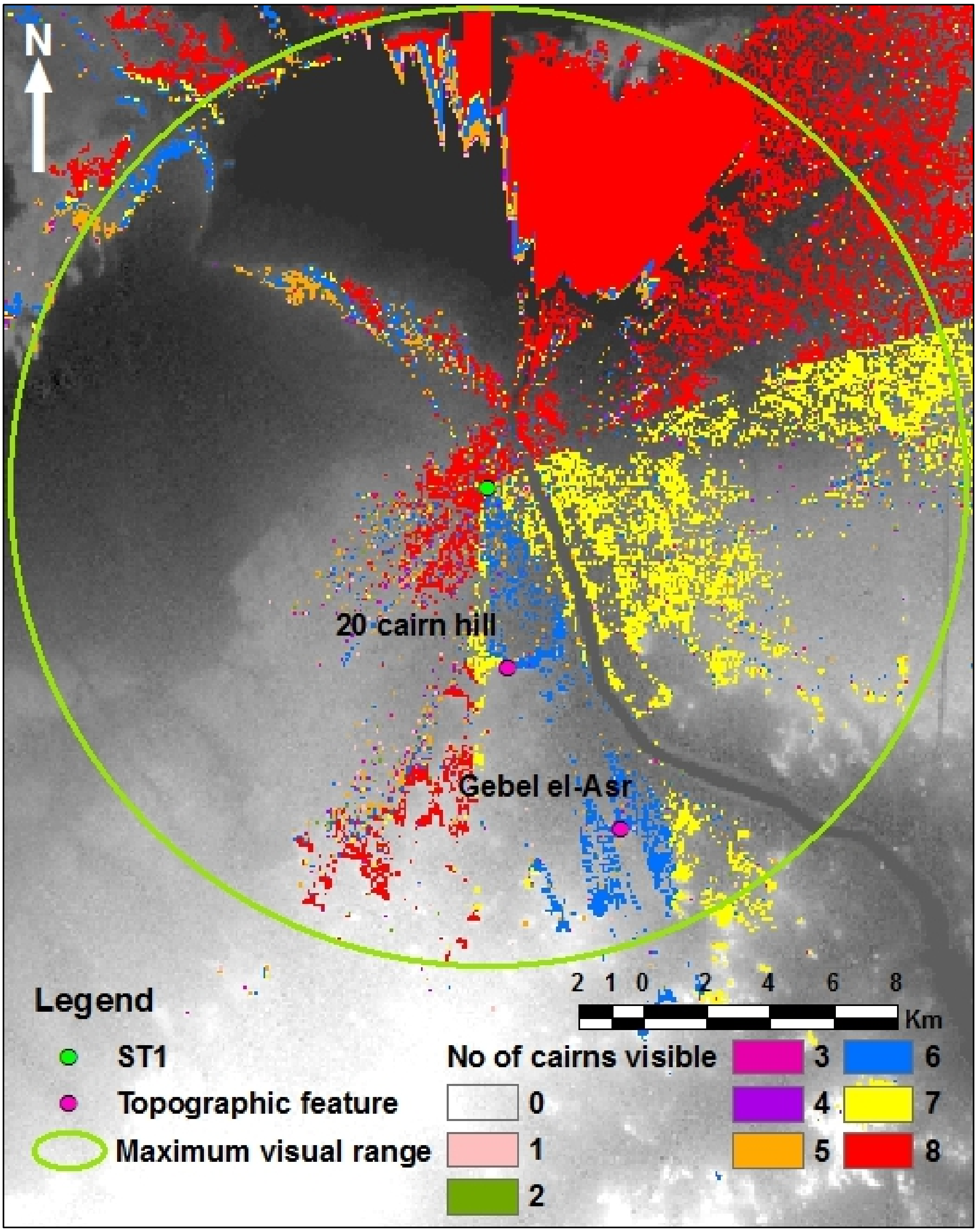


Fig 5.50: Reflective cumulative viewshed created using the revised cairn heights for cairns VII and VIII, showing from where the Stelae Ridge cairns could be seen and how many cairns could be seen. Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data available from the USGS).

Table 5.19: Areas of reflective cumulative viewsheds created using consistent cairn heights of 1.28m (left) and with revised cairn heights for cairn VII and cairn VIII (right).

No of cairns visible	Consistent cairn heights of 1.28m for all cairns			Revised heights for cairn VII and VIII		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)		Number	Area (km^2)	
1	372	2.78	1.43	372	2.78	1.43
2	269	2.01	1.03	268	2.00	1.03
3	271	2.03	1.04	279	2.09	1.07
4	325	2.43	1.25	318	2.38	1.22
5	1613	12.06	6.20	1608	12.02	6.18
6	3205	23.96	12.31	2896	21.65	11.12
7	4150	31.02	15.94	5230	39.10	20.09
8	15832	118.35	60.81	15066	112.62	57.86
Any (TVA)	26037	194.64	100	26037	194.64	100
<5	1237	9.25	4.75	1237	9.25	4.75
>=6	23187	173.33	89.05	23192	173.37	89.07
>=5	24800	185.39	95.25	24800	185.39	95.25

Observer points analysis

To determine how the different target heights of cairns VII and VIII affected the viewshed for Stelae Ridge north and the individual viewsheds for each cairn, an observer points analysis was run using the revised cairn heights and queried to obtain viewsheds for all the cairns on Stelae Ridge north and for cairns VII and VIII. The viewshed for Stelae Ridge south and the individual viewsheds for the other cairns will be the same as those presented in section 5.3.2, because the target height for all the other cairns remains consistent at 1.28m.

Fig 5.51 shows the inclusive and exclusive viewsheds where all the cairns on Stelae Ridge north were visible, using the revised target heights for cairns VII and VIII. The viewsheds shown in Fig 5.51 are very similar in appearance to the original viewshed in Fig 5.39a. The exclusive viewshed created with the revised cairn heights is the same 0.05km^2 as the original. The inclusive viewshed created with the revised cairn heights is smaller than the original at only 113.47km^2 or 58.30% of the total visible area. This is due to the lower height of cairn VII in the observer points analysis with revised cairn heights. With a lower target height the area where cairn VII is visible will be reduced and because cairn VII has the smallest viewshed this results in a corresponding reduction in the area where all the cairns on Stelae Ridge north are visible.

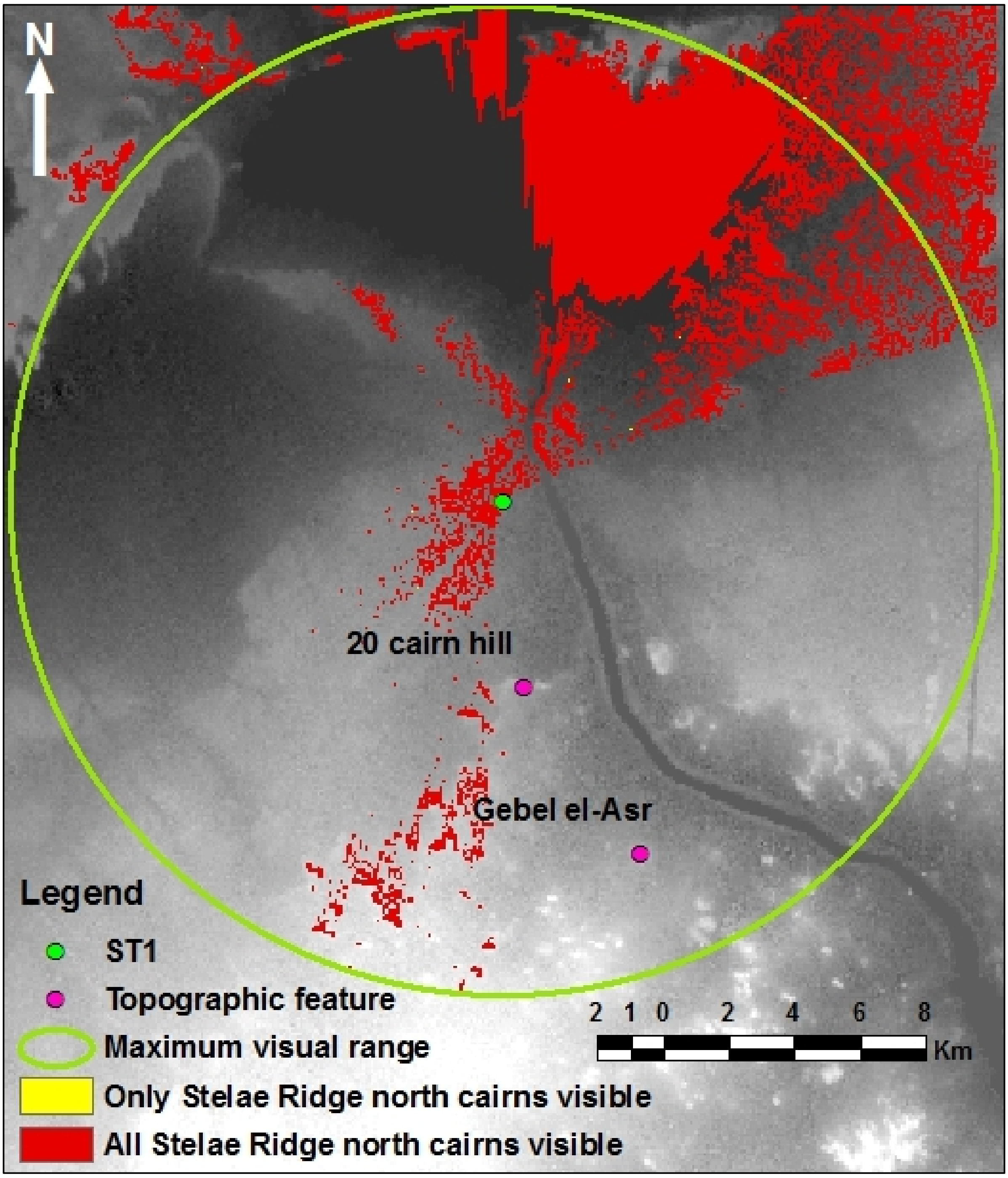


Fig 5.51: Reflective inclusive (red and yellow) and exclusive (yellow only) viewsheds for all the cairns on Stelae Ridge north created using the revised cairn target heights for cairns VII and VIII. Note that the exclusive viewshed is so small it is almost invisible. Viewsheds and vector data shown overlying SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS).

The individual viewsheds for cairn VII and cairn VIII were extracted from the observer points analysis and are shown in Fig 5.52 and Fig 5.53 respectively. The sizes of their viewsheds are recorded in Table 5.20 together with the sizes of the original viewsheds, created using the original cairn height of 1.28m.

Table 5.20: Areas of individual viewsheds for cairns VII and VIII, created using cairn heights of 1.28m (left) and with revised cairn heights (right).

Cairn	Heights of 1.28m for both cairns			Revised heights for cairn VII and VIII		
	Raster cells		Proportion of total visible area (%)	Raster cells		Proportion of total visible area (%)
	Number	Area (km^2)		Number	Area (km^2)	
VII	16131	120.59	61.95	15304	114.40	58.78
VIII	20193	150.95	77.56	20567	153.75	78.99
Any (TVA)	26037	194.64	100	26037	194.64	100

Table 5.20 shows that, as expected, the lower target height of 1.19m of cairn VII produces a smaller viewshed and the higher target height of 1.36m of cairn VIII produces a slightly larger viewshed. However, these slight changes do not alter the position of these cairns when the group is ordered by size, cairn VII still has the smallest and cairn VIII the next smallest viewshed.

Overall changing the heights of cairns VII and VIII to the surviving heights recorded during the 2012 survey made little difference to the overall pattern of viewshed and viewshed size for the Stelae Ridge cairns. However, it should be remembered that the original heights of cairns I-VI are not known and could not be tested. This group includes the cairns on Stelae Ridge south, whose ranking by viewshed size is sensitive to the presence of the azimuths and changes in target height. If it were possible to run the visibility analysis using the original heights of all the cairns, this might have an impact upon the conclusions concerning them.

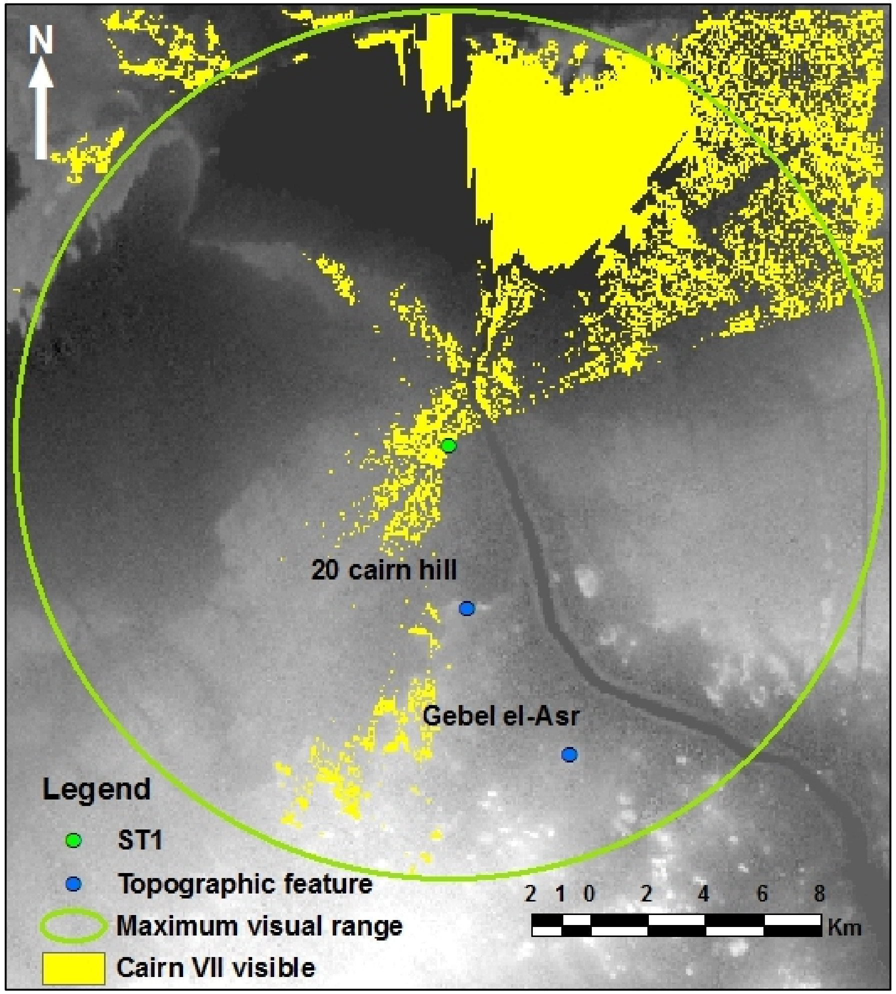


Fig 5.52: Reflective viewshed showing where a 1.19m high cairn VII would be visible.

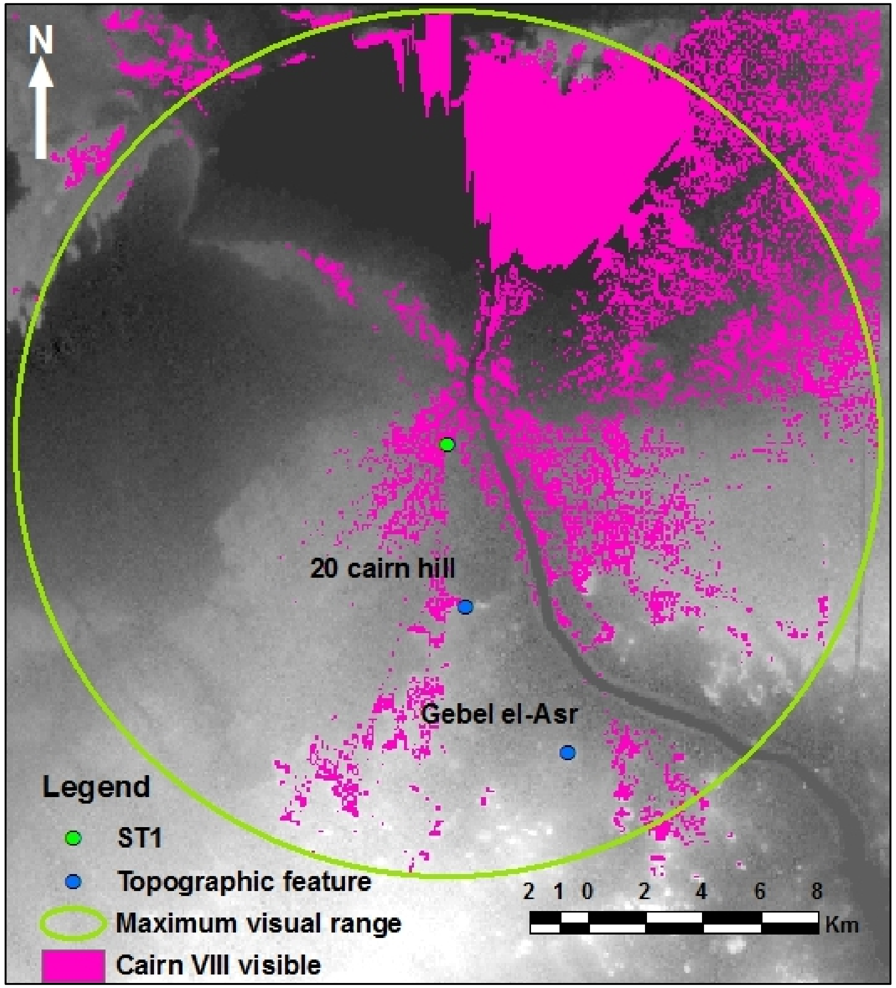


Fig 5.53: Reflective viewshed showing where a 1.36m high cairn VIII would be visible.

Viewsheds are shown overlying SRTM tilen22_e031_3arc_v2 (SRTM data from the USGS).

5.4.3. Conclusion

The visibility analysis of the cairns using a target height of 0m, revealed very little difference between the reflective visibility analysis of ground level at the cairns and ground level at the courts and generally supported the conclusions arrived at by the other visibility analyses. The only possible aspect of significance is that ground level at all eight of the cairns would have been visible from 7.86km^2 more of the landscape. This was probably because the inclusive viewshed for ground level at the Stelae Ridge north cairns, specifically cairns VI and VII, is larger than the equivalent viewshed for the courts. It implies that the location of these cairns was more visible than their courts, even prior to cairn construction, and probably reflects a deliberate choice to locate the cairns in the most visible position. During the visit to the site in 2012, the cairns of the two surviving cairn-courts on Stelae Ridge north were observed on the crest of the ridge, while their respective courts were slightly lower. This would be consistent with their apparent position in Engelbach's sketch plan in Chapter 3, section 3.2.1 Fig 3.1, which appears to show the cairns along the crests of the ridges and the courts slightly off the crests to the east.

The consistency between the better visibility from the cairns and their position at the centre of the ridge is a particularly interesting feature, because both court and cairn locations are set within the same SRTM cells and have the same height above sea level. The different visibilities of the cairns and the courts on Stelae Ridge north are not therefore due to variation in ground level on Stelae Ridge, but probably reflect different views across the landscape afforded by different positions on the ridge. They suggest that even though the SRTM is not sufficiently high resolution to show the detailed topography of the ridge, to some extent it has succeeded in revealing the relationship between position on the ridge and visibility. This is important because the very small variations between the visibilities of the structures on Stelae Ridge south would probably not be perceptible to a subjective human observer, and so could not have directly influenced the location of the cairn-courts. However, their different visibilities also reflect their different positions on the ridge and since it appears that visibility analysis with the SRTM is capable of expressing the relationship between visibility and position on the ridge, it is possible to draw meaningful conclusions from the slight differences between the viewsheds of the structures on Stelae Ridge south.

Running the visibility analysis using the surviving heights of cairns VII and VIII made little difference to the patterns in the results or the conclusions drawn from them, although it naturally had an effect upon the viewsheds of those cairns and for all cairns on Stelae Ridge north.

Overall, changes in observer location and to the height of the cairns had limited effect upon the visibility analysis and did not alter its conclusions. This suggests that the evidence presented in the visibility analysis is reasonably robust, in so far as it can be tested. Furthermore, testing of changes in observer location suggested that visibility analysis with the SRTM is capable of revealing the effect of slight differences in observer location, despite the SRTM's low resolution. While a higher resolution DEM, might provide more nuanced evidence, this does at least enable meaningful conclusions to be drawn from the visibility analysis about the deliberate positioning of structures on higher points along Stelae Ridge, even when the differences in their visibilities would not have been perceptible to a subjective observer.

Unfortunately while it might be possible to undertake visibility analysis using a higher resolution DEM in future, it is very unlikely that evidence of the original heights of the cairns can be located due to the limited records and recent damage to the site. These types of limitations to the visibility analysis are discussed in the next section.

5.5. Limitations of the visibility analysis

Throughout the visibility analysis an effort has been made to test parameters which were considered less than ideal. Testing the effects of the azimuths indicated that their presence did not alter the principle patterns within the data, and most of the conclusions reached using the visibility analysis with azimuths were also valid when it was undertaken without them. Re-running the visibility analysis using different heights for the two cairns where some evidence of the original height survived, also revealed minimal differences in the results and the conclusions drawn from them. However, if the original heights of all the cairns were known it is possible this might have an effect, particularly upon understanding of the structures on Stelae Ridge south, which proved very susceptible to changes in the parameters of the visibility analysis.

In Chapter 2, section 2.7.1 tests showed that a different GIS programme, using a different algorithm to calculate visibility, could produce different sizes and shapes of viewshed for the same point, when all other parameters were kept the same. The variation between the two different GIS programmes in both the size and shape of the viewsheds revealed that the choice of programme, and therefore algorithm, can have an impact upon the resulting viewsheds and any conclusions drawn from them. All the visibility analyses presented here have been undertaken in ArcGIS 10.1 to ensure that the algorithms used are consistent across the project and the viewsheds of different archaeological features and groups of features can be reasonably compared with each other. However, it was not possible to assess how far the ArcGIS 10.1 algorithm produced viewsheds consistent with real visibility because the precise method employed by ArcGIS 10.1 is not described in detail in the available literature, although comparison with the author's experience of visibility suggested that the smaller viewsheds produced by ArcGIS 10.1 were more likely to be closer to reality than those produced by the alternative programme. More detailed reinvestigation of the reality of visibility from each archaeological feature at the site might reveal how closely the viewsheds presented here reflect genuine visibility and further experimentation with different GIS programmes might confirm which algorithm produces the most reliable viewsheds, but this is beyond the scope of the current research.

There are other aspects of the visibility analysis which could be affected by the inputs to it and these inputs cannot be altered or tested to determine if they have influenced the conclusions. Most of these aspects relate to either the current condition of the site, the surviving documentation from the original excavations or the available DEM.

5.5.1. Current condition of the site and original documentation

The current damaged condition of the Stelae Ridge cairns has placed considerable limitations upon the research. By preventing modern survey of the original site, it made it impossible to include the original heights of five of the cairns and called into question the heights of the surviving cairns. Possibly inaccurate cairn heights introduce an element of uncertainty and the potential for error, into both the visibility analysis of the cairns and their impact on the visibility analysis of the courts.

The damage to the site makes the visibility analysis dependent upon the records made during the original excavation, specifically Engelbach's (1939) sketch plan, and increases the difficulty in georeferencing those records,[267] raising doubt over the accuracy of the rectified sketch and the observer locations and azimuths derived from it. Changing the observer locations could alter the azimuths, and alterations to both could change the results of the visibility analysis. The visibility analysis undertaken without azimuths goes some way to controlling for the effect of this,[268] but it would be preferable to have better locational data as to the positions of the courts and cairns and the height of the latter.

---

[267] For the records of Engelbach's excavations Chapter 3, section 3.2–3.3. For the problems encountered georeferencing Engelbach's plan, see Chapter 3, section 3.9.1.
[268] For the visibility analysis without azimuths see above section 5.2.

5.5.2. The SRTM digital elevation model

The visibility analysis made use of the SRTM DEM because it had the best combination of resolution and accuracy available to this project.[269] Inherent in the SRTM are a number of factors which place limitations upon the visibility analysis.

Topography

In Chapter 4, section 4.5 and 4.6 the modern alterations to the topography around Stelae Ridge were identified and it was decided to leave these in the SRTM for the visibility analysis, rather than alter the SRTM to conform to a possibly false idea of what the Middle Kingdom topography was. It is recognised that the modern alterations to the landscape represent a deviation from the Middle Kingdom landscape, most particularly in the area occupied by the main canal and the Tushka Lakes, and inevitably alter the results of the visibility analysis in this area.[270]

However, the canal and the Tushka Lakes are consistent across the entire visibility analysis and all viewsheds are therefore equally susceptible to them. The Tushka Lakes are located at least 7km from Stelae Ridge and occupied a depression in the landscape, so visibility in this area is likely to have been consistently overestimated as the water level of the lake in the SRTM is higher than the underlying ground surface. The distance from Stelae Ridge means even if ground level beneath the lakes was theoretically visible, it is doubtful whether anything but the largest topographic features would have been visible to the human observer over the 7km distance. Only the largest landforms, such as the Gebel el-Asr itself, were visible to the author from Stelae Ridge during the visit to the site in 2012 and very little was visible to the north of Stelae Ridge beyond the compound on the Gebel Uweinat road.[271] Visibility certainly did not extend as far as the Tushka Lakes and this will be remembered when visibility from Stelae Ridge is considered in Chapter 6. Otherwise the only impact of the Tushka Lakes upon the visibility analysis is the likely overestimation of viewshed size resulting from the inclusion of the lakes in the viewsheds and this is limited by the small amount of the Tushka Lakes included within the 15km maximum visual range.

The main canal is much closer to Stelae Ridge. Given the general flatness of the landscape, where any given viewshed appears on both sides of the canal, it would likely originally have extended across the canal. The presence of the lower bed of the canal might reduce the size

---

[269] For the problems with the ASTER GDEM2 and choice of the SRTM as the DEM for this project see Chapter 4 section 4.2.3.
[270] For the Tushka Lakes see Chapter 4, section 4.5.2, Fig 4.16 and Fig 4.18.
[271] For the experience of visibility at the site see Chapter 3, section 3.7.3.

of those viewsheds which extend into it, but the higher spoil heaps on each side will probably slightly increase those viewsheds, balancing out the reduction to a certain extent. A greater problem is the physical impact of the canal in removing or obscuring landforms that might have been significant in the past.

One further area in which the SRTM might not reflect the original landscape is around Stelae Ridge itself. The area of modern demolition around Stelae Ridge south was apparent on Landsat imagery from 1984 onwards.[272] The creation of this feature presumably included the demolition of cairns I-V and alterations to the shape of the original ridge, but it is not known whether it altered the height of the ridge. The visibility analysis has shown that there are distinct differences between the viewsheds of the structures on the two ridges, and these differences are partly due to the height of the ridges. Given that it was 2m higher, Stelae Ridge south would naturally have better visibility than Stelae Ridge north. If ground level on Stelae Ridge south had been substantially altered by modern activity, any conclusions based upon the differences between the two ridges would be called into question.

It is difficult to be certain whether the ground level of Stelae Ridge south has been altered significantly. Comparison with the Engelbach sketch reveals that the shape of the ridge has almost entirely disappeared. However, it is impossible to know how precisely Engelbach drew the ridge or its contours. Even if modern activity has altered the shape of the ridge, it need not necessarily have altered its height by a substantial amount.

Experience at the site in 2012 indicated that Stelae Ridge south was already a high point in the landscape even before modern intervention. When standing on Stelae Ridge north and looking south, the original ground surface clearly drops into a shallow depression at the south end of the northern ridge, before rising again towards the remains of the southern ridge.[273] The original ground surface is then lost in scatters of stone moved by modern activity. These might have increased the height of the ridge to a certain extent, but the amount of stone required and the purposelessness of the task suggest that it has probably not risen by 2m!

Resolution

The resolution and cell size of the SRTM also constitute a limitation. The SRTM has a resolution of just under *c.* 90m and this is matched by its cell size. The coarse rendering of

---

[272] For Landsat imagery see Chapter 4 section 4.5.2.
[273] For the author's experience of the site in 2012 see Chapter 3, section 3.7.3. For photographs showing the duricrust ground surface rising up to Stelae Ridge south see Fig 3.26 and Fig 3.27a.

the landscape does not represent a significant difficulty for distant features since these have to be large to be visible anyway, and it actually helps reduce the effect of smaller modern alterations to the landscape.

However, the resolution of the SRTM has some implications for the visibility analysis in the area around Stelae Ridge. The resolution of the SRTM is too coarse to represent accurately the two ridges. Cairns I–VI are located in the 194m above sea level SRTM cell and cairns VII and VIII in the 192m cell. Any slight variation in ground level between individual cairns or courts and any larger variation between the ridges and the land adjacent to them has been completely obscured, producing abrupt changes in height from one SRTM cell to the next. Some effort was made to reduce the abruptness of these changes in the visibility analysis with cairn-court VI given a ground level of 193m,[274] but the nature and size of the SRTM cells have significant implications. It is likely that some of the differences between the viewsheds for cairn-courts on the northern ridge is due to the 1m difference in ground level between cairn-court VI at 193m and cairn-courts VII and VIII at 192m. Equally the very similar viewsheds of cairn-courts I-V are probably partly because they all had the same ground level of 194m.

The differences in ground level on the two ridges also explains why there is such low visibility between the cairn-courts on Stelae Ridge north and the area to the south and east of the site. At 192m, ground level at most of the Stelae Ridge north cairn-courts is too low for either a 1.6m observer or a 1.28m cairn to be inter-visible with the landscape on the other side of the 194m high area of Stelae Ridge south.

Although the abruptness of the height difference between the two SRTM cells is not ideal, whether it represents a coarsening of genuine differences or an artificial construct is down to whether the heights of the ridges have been substantially altered. In the previous section it was suggested that the height of Stelae Ridge south has probably not been significantly increased compared to its Middle Kingdom level. Since there is little evidence of change to the height of Stelae Ridge north, it does seem probable that the differences in height shown in the SRTM are broadly accurate for the Middle Kingdom landscape, even though the SRTM renders them rather coarsely.

The visibility analysis of ground level at the cairns presented in section 5.4.1 and discussed in section 5.4.3 also suggests that visibility analysis with the SRTM has revealed genuine differences in the visibility of different locations, even though they are located in the same

---

[274] For the ground level in the visibility analysis see Chapter 2, section 2.6.2.

SRTM cell and have the same ground level. This conclusion is supported by the correlation between cairn-court II's position on the edge of Stelae Ridge, in a more peripheral location, and its low visibility compared to the other structures on the ridge.

5.6. Conclusion

Although a number of limitations affect the visibility analysis undertaken here, where these have been tested they have been shown to have a minimal effect upon the results. Untested problems, such as the resolution of the SRTM and modern alterations to the landscape, could represent more significant limitations. Although less than ideal, the available evidence suggests that the modern alterations to the landscape are unlikely to have altered the landscape so much that the general conclusions of the visibility analysis are untenable. The low resolution of the SRTM is not ideal in the area around Stelae Ridge, but it cannot be avoided and further from the site may actually have helped to reduce the effect of modern structures upon the landscape model.

The results of the reflective visibility analysis of the cairns broadly support the evidence from the visibility analysis of the courts, with and without azimuths, which revealed that there is a significant difference between the structures on the northern and southern ridges. The structures on the southern ridge are much more widely visible, particularly to the south, and have a much better view. They are best located for good views of the surrounding landscape and would have made good markers for travellers moving towards Stelae Ridge, particularly from the gneiss quarries to the south and the south-easterly track to the Nile. Their viewsheds are also much more consistent with each other and slight alterations in the location, target height or azimuths can affect which structure had the largest or smallest viewshed on Stelae Ridge south. Since the sizes of the viewsheds of cairn-courts I-V probably relate to their positions on the ridge and therefore to decisions about their precise location and the order in which they were constructed, the visibility analysis of the courts without azimuths and of ground level at the cairns provide useful controls for the effect of these parameters upon the other visibility analyses.

The structures on the northern ridge, particularly cairn-court VII and cairn-court VIII are less visible and have a less extensive view of the landscape. They are not visible from 20 cairn hill or the Gebel el-Asr and would not have made good landmarks for those approaching from the south. Since both these structures appear to be later additions to the sequence in the reign of Amenemhat III, the earlier cairns on the southern ridge would have provided the necessary landmarks for those approaching from the south. However, the more northerly structures would have been closer to, and more visible from, the area of mining activity to the north and west of Stelae Ridge. This may also have influenced their construction.

6. Interpretation of the visibility analysis

Following the systematic visibility analysis of the eight structures on Stelae Ridge, presented in Chapter 5, the results of the visibility analysis and the conclusions drawn from it were interpreted with reference to the archaeological and epigraphic evidence from the site, in the context of the broader historical period and relevant evidence from comparable sites. This included comparison of the results of the visibility analysis with the archaeological and topographic features in the landscape, re-evaluation of the probable location of 20 cairn hill in view of new evidence from the visibility analysis, a new model for the chronological development of the Stelae Ridge structures, and consideration of possible alternatives to Stelae Ridge and the factors which governed the choice of this location for the cairn-courts.

Where necessary new research has been undertaken in the GIS, using the records of past archaeological investigations to locate significant topographic and archaeological features and compare them with viewsheds provided by the visibility analysis. In addition, some new visibility analysis has been undertaken to determine whether Stelae Ridge offered better visibility than other nearby ridges, which could have provided alternative locations for the cairn-courts. The results of this new research have been combined with the systematic visibility analysis and other evidence to understand how the visibility offered by Stelae Ridge connected it to other archaeological and topographic features and assess whether this particular ridge was chosen because of that visibility.

6.1. Interconnected landscapes

The systematic visibility analysis in Chapter 5 revealed that, as expected of structures on a ridge, the cairn-courts were very visible and had a good view of the landscape. This section considers what parts of the landscape, archaeological and topographic features could be seen from them and from where the cairn-courts could be seen.

Although both cairn and court of a single structure exhibited similar visual properties, it is obvious from both their construction and their larger reflective viewsheds that the cairns were intended to be the visible component. The courts, as locus for the deposition of artefacts and any associated rituals, were places where people undertook activities and therefore places from which the landscape would be viewed. Given this distinction discussions of the views from the structures relate to the views from the courts, while discussions of the visibility of the structures reflect the visibility of the cairns.

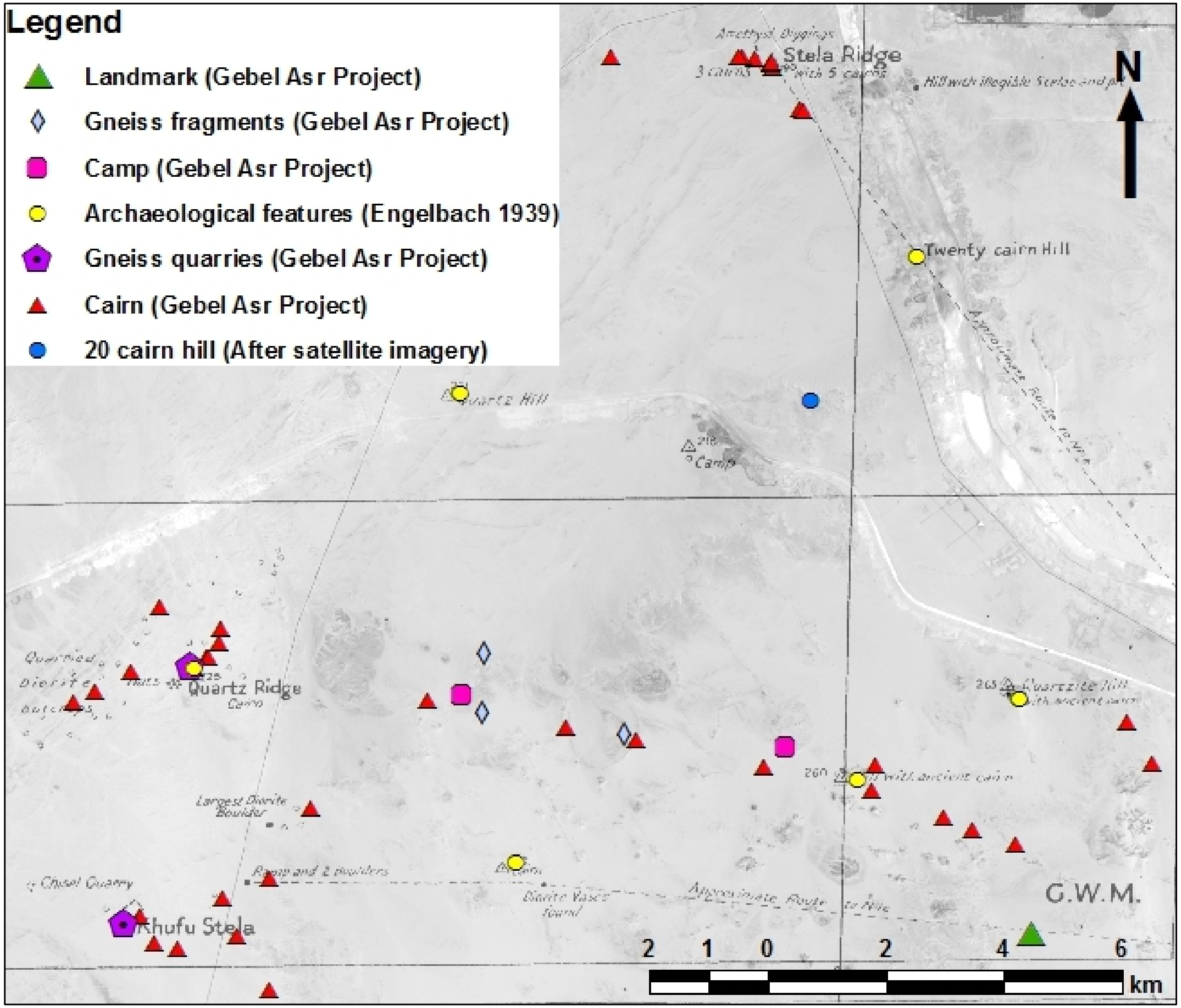


Fig 6.1: The Gebel el-Asr quarries shown on the Landsat 8 image from 2013, overlaid with Engelbach's 1:100,000 scale sketch plan of the quarries. Archaeological features identified from Engelbach's plan are shown in yellow. Note the difference between the position of the track from Quartz Ridge to the Nile outlined by cairns recorded by the Gebel el-Asr Project, and the more southerly track from Khufu Stela recorded by Engelbach. The position for 20 cairn hill recorded by Engelbach is also very different from the position suggested by the satellite images and research at the site. (Landsat data from the USGS)

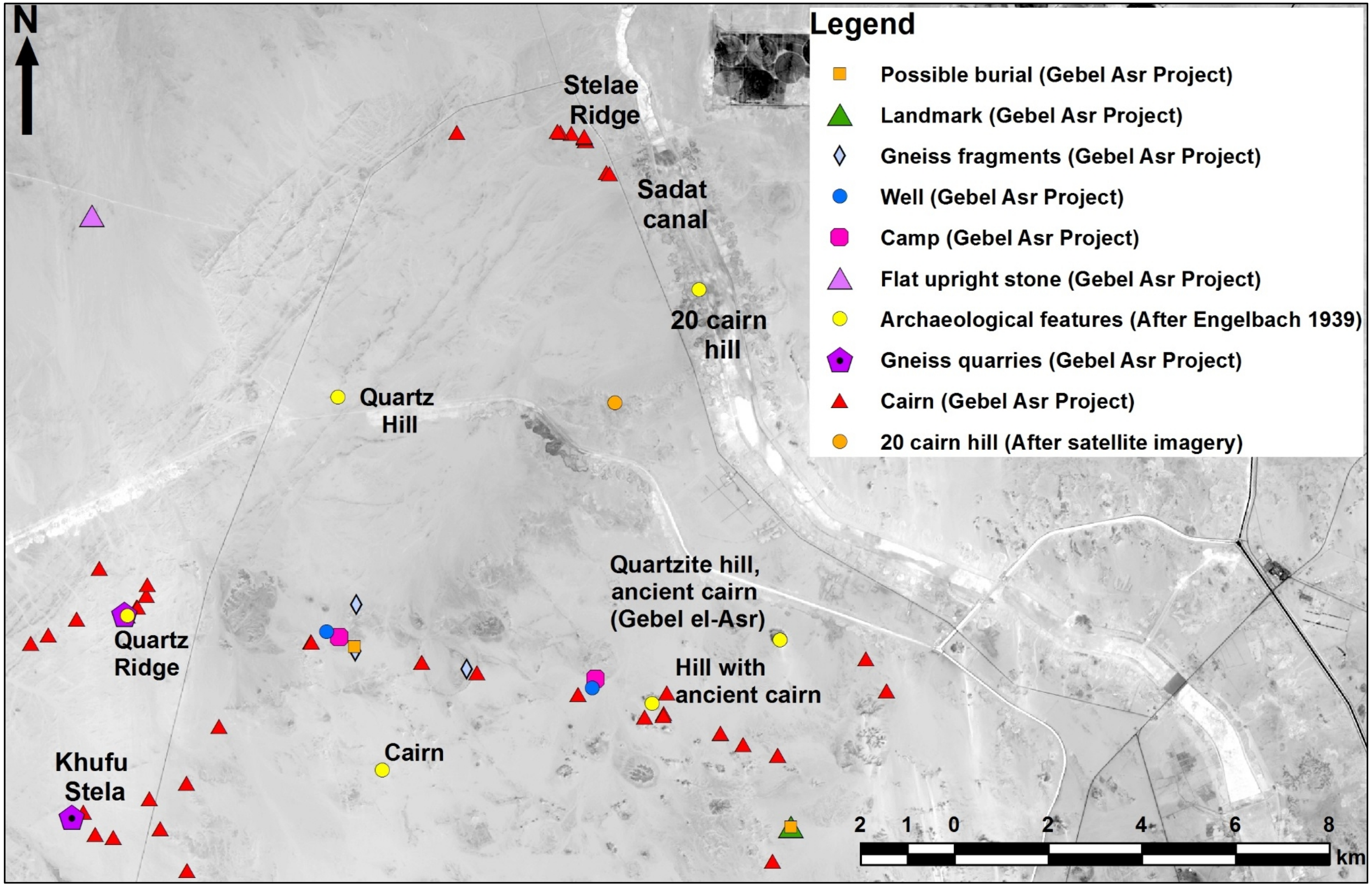


Fig 6.2: The Gebel el-Asr quarries shown on the Landsat 8 image from 2013, with archaeological features from Engelbach's map and the Gebel el-Asr Project. (Landsat data from the USGS)

To contextualise the visibility analysis, the archaeological and topographic features in the landscape around Stelae Ridge were incorporated into the GIS research.[275] Engelbach's georeferenced sketch plan of the Gebel el-Asr quarries was compared to heights recorded in the SRTM and the landforms visible in the Landsat 8 image from 2013 to identify locations that might have been relevant to Egyptians working at Stelae Ridge or moving around the landscape between different areas of activity (Fig 6.1).[276]

Comparison of the archaeological and topographic locations recorded by Engelbach, and those recorded by the Gebel el-Asr Project data revealed that these two sources were generally consistent with each other (Fig 6.2), but there were some exceptions. There are notable differences between Engelbach's 'Approximate route to the Nile' and the track identified by the Gebel el-Asr Project, and between Engelbach's location for 20 cairn hill and that proposed by the author, based on satellite imagery and the visit to the site in 2012.

6.1.1. Twenty Cairn Ridge

Engelbach's location for '20 cairn hill' was 3km north-east of the ridge identified as the most likely location for 20 cairn hill by the author during research with satellite imagery and on the site.[277] It is possible that the 20 cairn hill described by Engelbach was located roughly where he indicated and had been entirely destroyed by the main (or Sadat) canal of the Tushka Project.[278] The CORONA imagery shows several small hills which were clearly removed by the canal (Fig 6.3), but identifying one of these hills with 20 cairn hill does not resolve the problem. It does not explain Engelbach's confused description of the site or the fact that apparently he took no notice of the notched ridge to the south of Stelae Ridge, which was dotted with cairns and dominated the landscape.[279]

---

[275] These features are shown on Engelbach's sketch plan of the Gebel el-Asr quarries, which is discussed in Chapter 3, section 3.3.2 and 3.9.3.

[276] For the SRTM DEM see Chapter 4, section 4.2.2 and for the Landsat 8 imagery see Chapter 4, section 4.5.2.

[277] For the identification of 20 cairn hill based on research at the site and in satellite imagery see Chapter 3, section 3.3.2, 3.7.3 and Chapter 4, section 4.5.2.

[278] It is not surprising that no hill is visible on the CORONA image (Fig 6.3) exactly where Engelbach places 20 cairn hill, because Engelbach's plan is a sketch and is also subject to some georeferencing errors (Chapter 3, section 3.9.3), and there is also error associated with the location of the CORONA photograph (Chapter 3, section 3.8).

[279] For the dominance of the notched ridge over the Stelae Ridge landscape see Chapter 3, section 3.7.3.

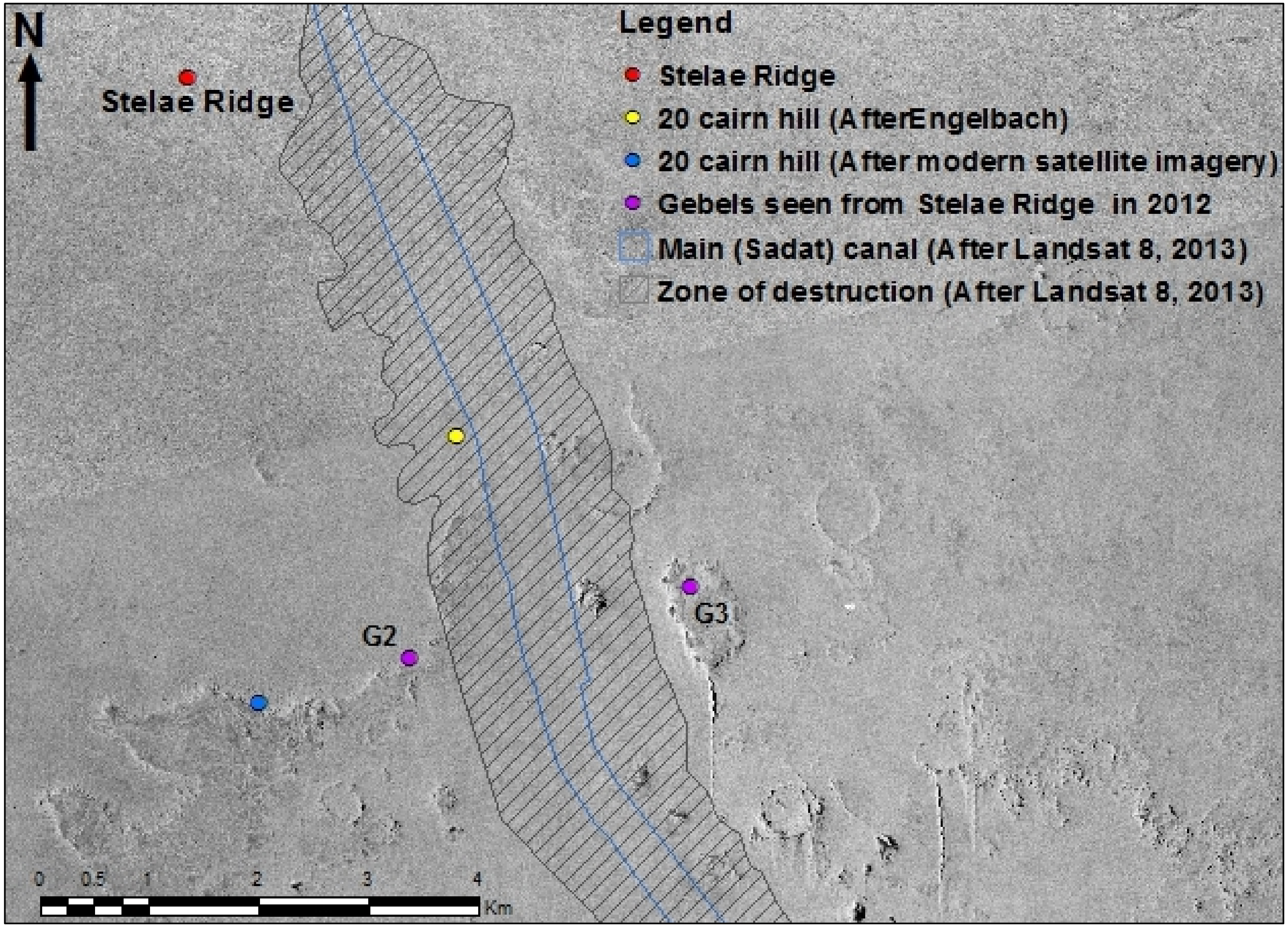


Fig 6.3: CORONA imagery, showing possible candidates for Engelbach's 20 cairn hill in the footprint of the main canal and its surrounding zone of destruction. (CORONA data from Centre for Advanced Spatial Technologies, University of Arkansas/USGS)

The visibility analysis resolved this problem. It revealed an area to the south of the 20 cairn hill identified by Engelbach, which had a view of all the cairns and was visible from all the courts on Stelae Ridge south (Area A on Fig 6.4). This area, Area A, has a height of 191–197m above sea level, but was not identifiable on the Landsat imagery because it appeared to be one of the spoil heaps of the main canal. The size and consistency of the feature on the SRTM suggest it is not just a spoil heap and it can also be identified in the CORONA imagery.

To the south of Area A is the continuation of the notched ridge, which includes the small rise observed during the visit to the site and given the designator G2.[280] Comparison with the CORONA image (Fig 6.5), reveals that the ridge originally extended further north-east to Area A and beyond, into what is now the main canal of the Tushka Project, almost as far as Engelbach's position for 20 cairn hill.

Taken together the various different pieces of evidence suggest that 20 cairn hill was not a single hill, but a ridge running south-west from the area marked as 20 cairn hill by Engelbach to the western end of the notched ridge, observed in the satellite imagery and during the visit to the site. The north-eastern part of the ridge probably included Engelbach's 20 cairn hill and was removed by the main canal. The surviving area is shown hatched on Fig 6.4 and Fig 6.5.

Taken as a single topographic feature, the ridge forms the last high point for any traveller approaching Stelae Ridge on any bearing between 140° and 195°.[281] This explains the differences between the author's identification of '20 cairn hill' *c.* 5.8km from Stelae Ridge on a bearing of 160°, and Engelbach's (1933, 69) *c.* 5.2km from Stelae Ridge on a bearing of 144°. Engelbach's 20 cairn hill was the north-eastern end of the ridge, which was removed by the Sadat canal, leaving the author to identify Twenty Cairn Ridge with the more southerly section that now dominates the landscape. Such a large ridge would have made a good landmark for anyone approaching Stelae Ridge either from the Nile to the south-east, or from the gneiss quarries to the south-west. Multiple locations along this ridge attracted cairns, explaining some of the ambiguity in Engelbach's (1933, 69; 1938, 388) description, which sometimes involves 13 and sometimes 20 cairns.

[280] For the topographic features visible from Stelae Ridge see Chapter 3, section 3.7.3, particularly Fig 3.29 and Fig 3.30.
[281] See Chapter 3, section 3.7.3 and Fig 3.29 for the circular view which shows every landform visible for 360° around Stelae Ridge. The ridge is labelled '20 cairn hill' and the adjacent rise labelled G2, is actually the easternmost end of the ridge.

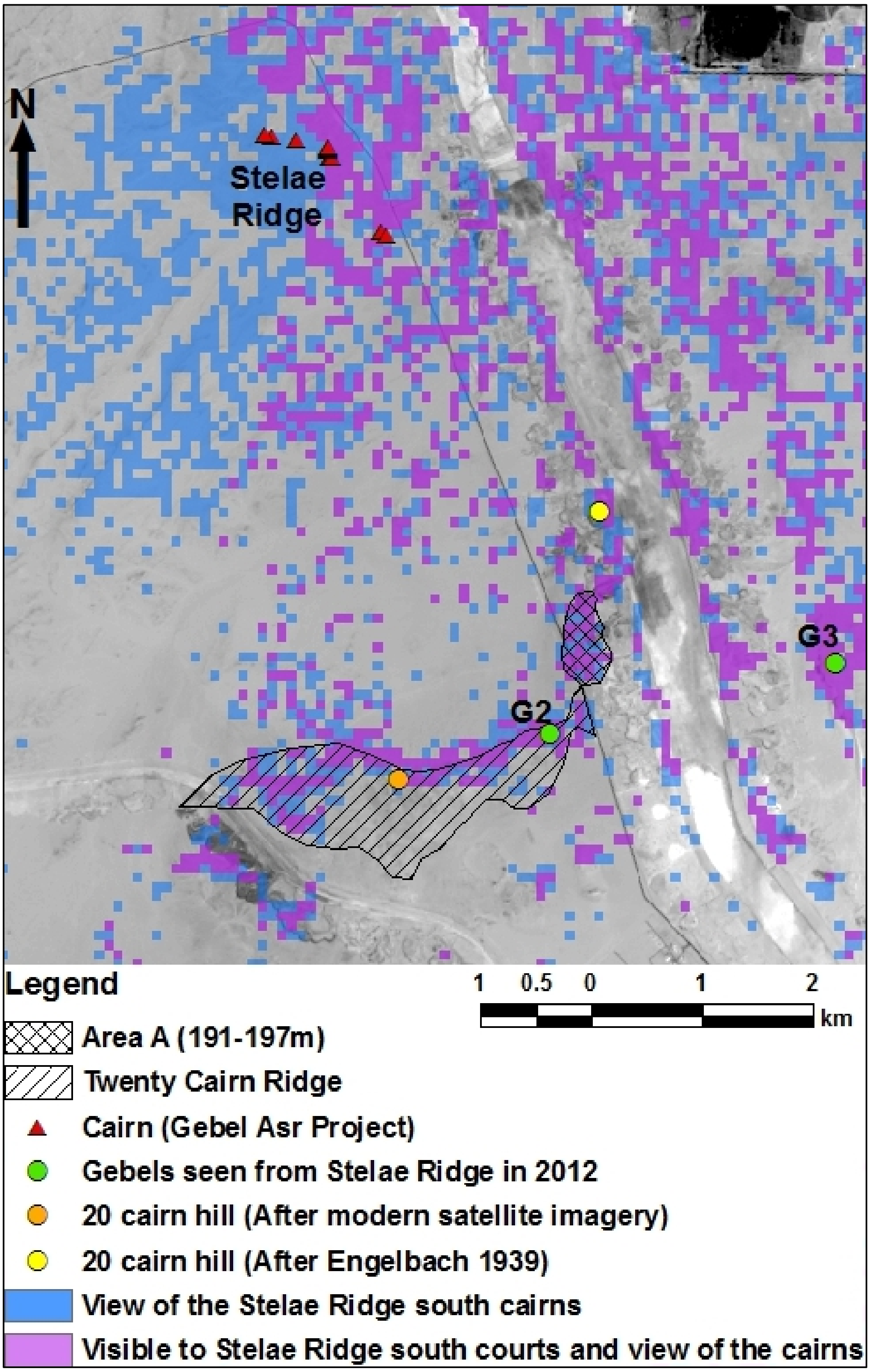


Fig 6.4: Detail of the Twenty Cairn Ridge area, showing the location of 20 cairn hill as described by Engelbach, the entire surviving section of Twenty Cairn Ridge (hatched) running west from the Gebel Uweinat road, and Area A (cross-hatched). (Landsat 8 satellite image from USGS).

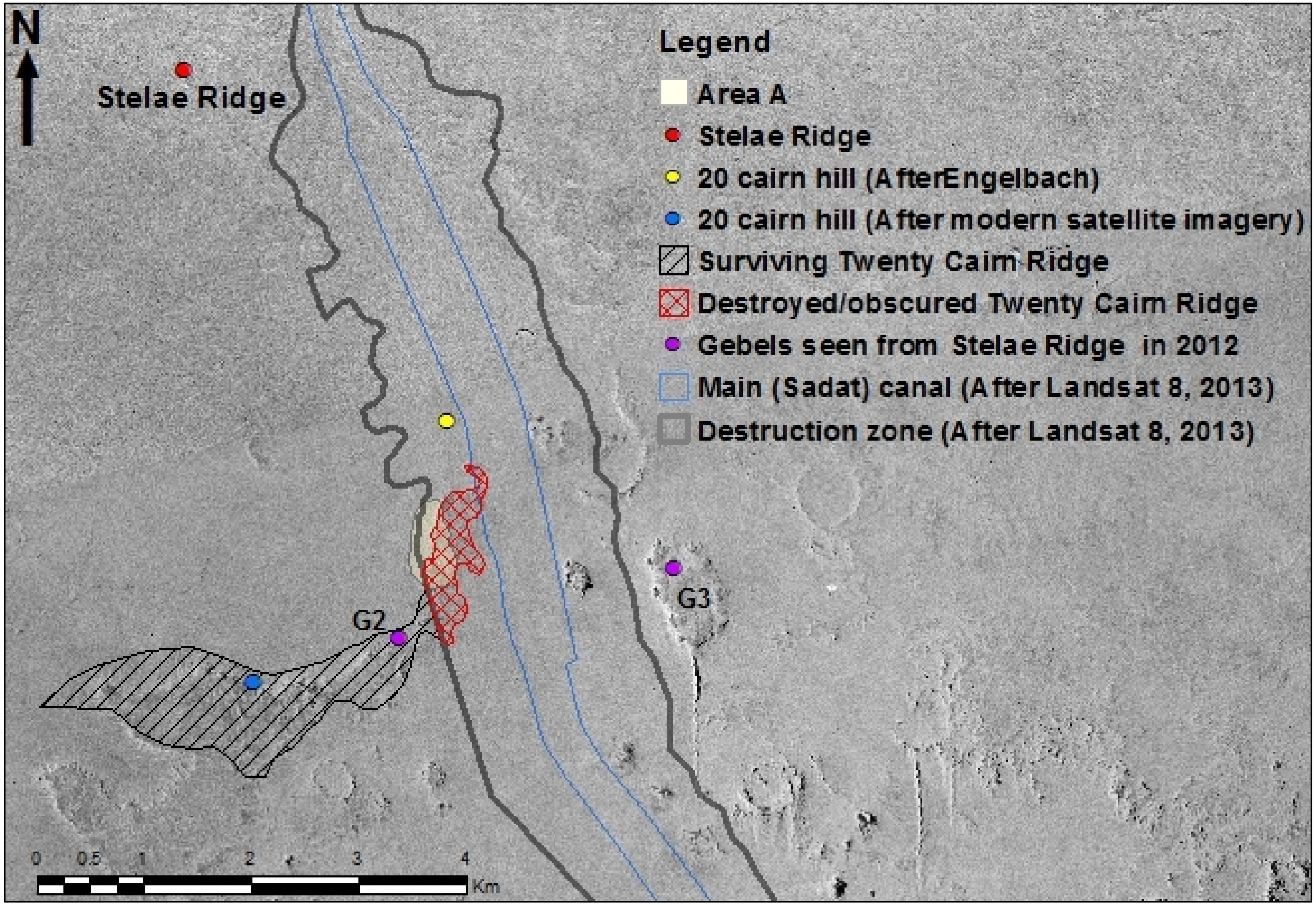


Fig 6.5: CORONA imagery, showing how Twenty Cairn Ridge originally extended northwards into the zone of destruction around the main canal, including Area A and reaching almost as far north as Engelbach's position for 20 cairn hill. (CORONA data from CAST/USGS)

6.1.2. Tracks

When combined with the Gebel el-Asr Project survey data, Engelbach's sketch plan of the Gebel el-Asr quarries suggested some possible routes across the quarry landscape (Fig 6.6), in addition to the two recorded by Engelbach on Fig 6.1. Together with the visibility analysis, these tracks provide new insights into the interconnections between the archaeological loci across the Gebel el-Asr quarries and the process of route finding and route marking.

In addition to Stelae Ridge, there is evidence of Middle Kingdom activity at Quartz Ridge, which probably formed the centre of operations, and at several locations recorded by the Gebel el-Asr Project, along the route between Quartz Ridge and the Nile.[282] Fig 6.7 shows the total area visible to any of the courts at Stelae Ridge and the total area from which any of the cairns were visible. It indicates that neither Quartz Ridge nor Khufu Stela quarry would have been visible from Stelae Ridge and Khufu Stela quarry is actually beyond the 15km maximum visual range. This would have effectively prevented travellers from simply heading to or from Stelae Ridge across the desert, at least until they were more familiar with the landscape, and it is likely that they made use of several intermediate landmarks and predetermined routes.

The track between Quartz Ridge and the Nile

The track between Quartz Ridge and the Nile was recorded by Engelbach (1939) in his sketch plan of the Gebel el-Asr quarries. The archaeological sites along it were also recorded by the Gebel el-Asr Project. However, Fig 6.1 shows that the Gebel el-Asr Project recorded the track 1.3–3.0km north of the 'Approximate route to the Nile' suggested by Engelbach. This is probably due to errors in georeferencing or imprecision in Engelbach's sketch, but there may also be two tracks. The Gebel el-Asr Project recorded a natural landmark with a possible burial and a hill with a cairn *c.* 2km south of the other archaeological features along the track (Fig 6.6), at what would be the eastern end of Engelbach's 'Approximate route to the Nile'.

---

[282] For the Middle Kingdom activity at Quartz Ridge see Shaw *et al.* (2010, 299–203) and for the archaeological sites between Quartz Ridge and the Nile see Shaw and Heldal (2003, 16) and Shaw *et al.* (2010, 304).

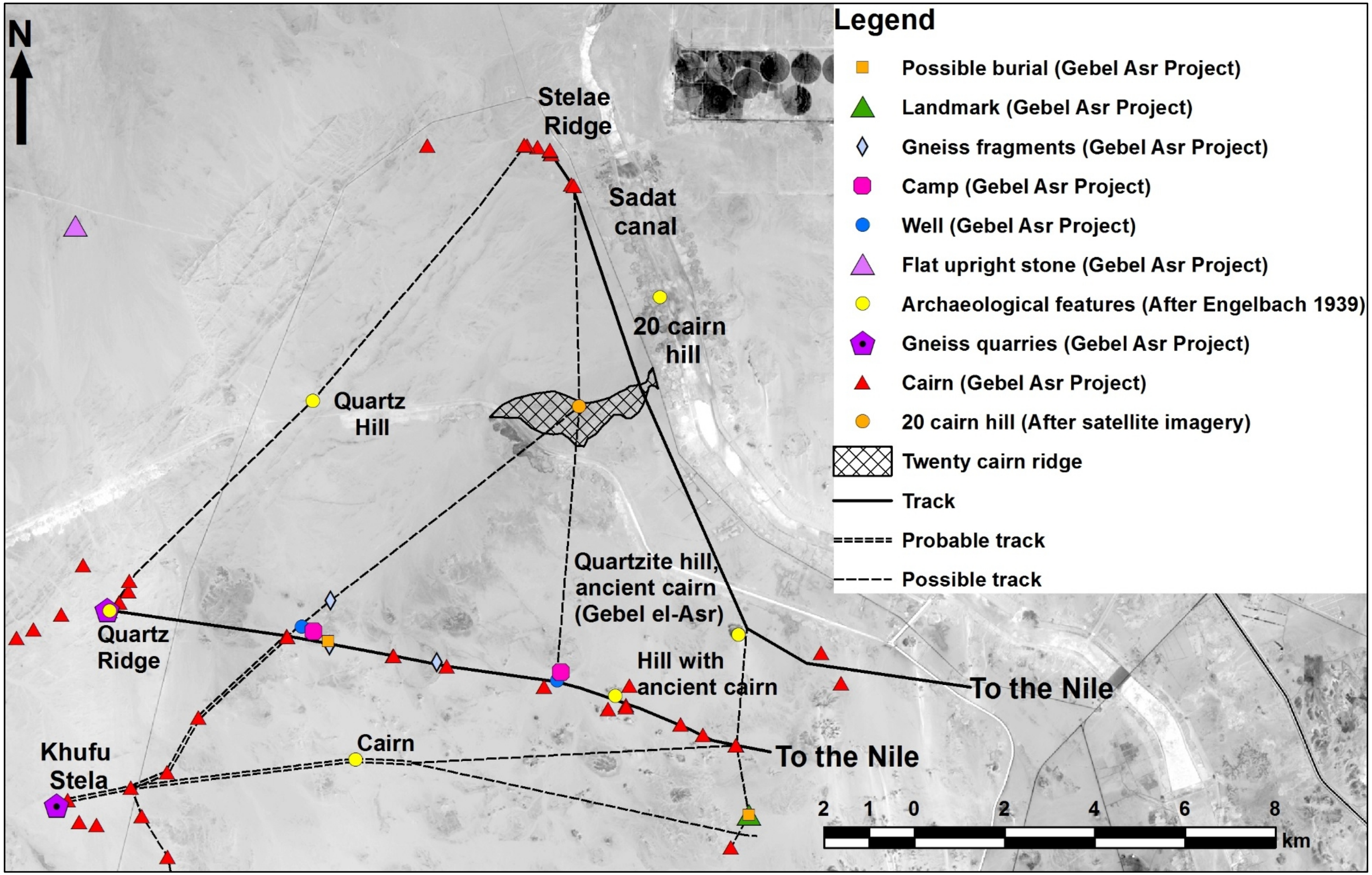


Fig 6.6: The Gebel el-Asr quarries showing known, probable and possible tracks based on the archaeological features recorded by Engelbach and the Gebel el-Asr Project, overlying Landsat 8 panchromatic band (Band 8), 2013. (Satellite imagery from USGS).

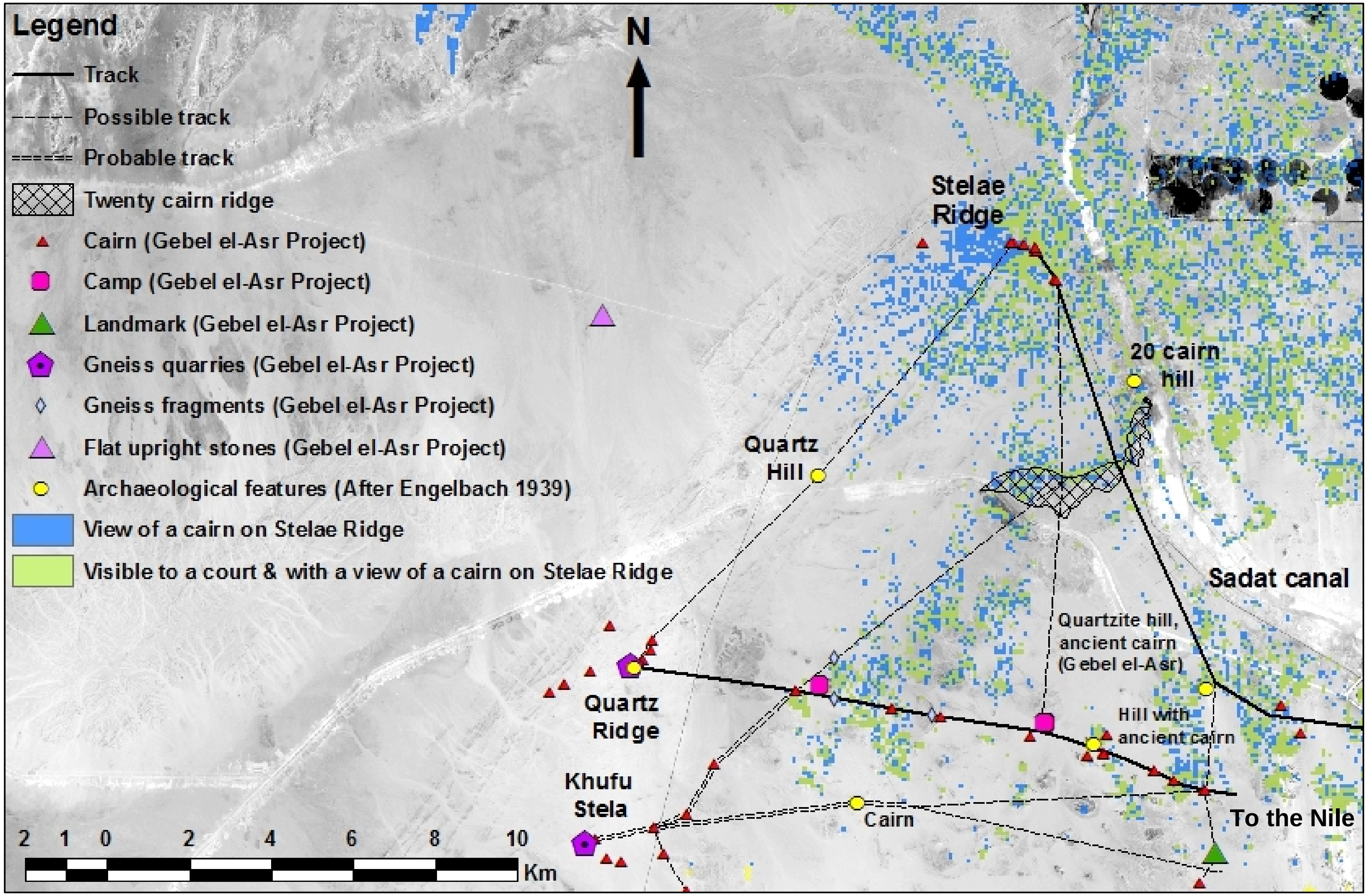


Fig 6.7: The total area visible to any of the courts (green) and the total area from which any of the cairns were visible (blue and green), shown overlying Landsat 8, panchromatic band (Band 8) from 2013. (Satellite imagery from USGS).

A detailed review of the viewsheds shown in Fig 6.7 indicates that many of the cairns and other archaeological features recorded by Engelbach (1939) and the Gebel el-Asr Project along the route to the Nile, are located on or close to, areas which were visible to and had views of Stelae Ridge. While it is extremely unlikely that the more distant of these areas were actually visible from Stelae Ridge, to be classified as inter-visible with Stelae Ridge across such a distance implies that these areas are not located in hidden dips, but are reasonably prominent in the landscape. This prominence made these hills or ridges attractive as landmarks to those who used the route and prompted them to construct cairns on or near these prominent features. Naturally, there are some cairns which do not appear to be located close to any prominent features at all, but this probably reflects the multi-purpose nature of the cairn. Cairns could identify discrete structures like camps or wells, mark the route across lower terrain where other landmarks were absent, as well as enhancing prominent landmarks and reassuring travellers they were following the right ones.

The track south-east from Stelae Ridge towards the Nile

The route south-east from Stelae Ridge to Twenty Cairn Ridge and on towards the Nile is recorded by Engelbach (1933, 68; 1939, 309) and four cairns probably on the route were recorded by the Gebel el-Asr project. Two of these cairns were *c.* 870m south-east of Stelae Ridge and inter-visible with it and the other two were east of the Gebel el-Asr hill itself. Both the visibility analysis and experience of visibility at the site indicated that the Gebel el-Asr was visible from Stelae Ridge, although practical experience suggest this was only under good conditions. Although the two cairns to the east of the Gebel el-Asr were too far away from Stelae Ridge to be practically visible, as with some other cairns, they must have been located in a prominent position to be classified as inter-visible with Stelae Ridge.

Engelbach recorded that Twenty Cairn Ridge was either the last or the first location with a view of Stelae Ridge, depending on whether the observer was moving away from or towards the site (1939, 388). Both the visibility analysis and experience of visibility at the site confirms the dominance of the ridge, although not the particular area indicated by Engelbach, which had since been removed by the main canal. Given that areas beyond Twenty Cairn Ridge would only have been visible from Stelae Ridge under the best conditions, it would have been even more important a landmark than the visibility analysis suggests.

Other routes within the quarries

Given the Middle Kingdom activity at Quartz Ridge, it is reasonable to assume there would have been movement between Quartz Ridge and Stelae Ridge. Travelling eastwards along the route to the Nile before turning northwards at the Gebel el-Asr would have made the journey unnecessarily long, so it is likely that another track or tracks existed, giving easier access to Stelae Ridge from Quartz Ridge. Fig 6.6 shows some possible routes, one via Quartz Hill and two via Twenty Cairn Ridge, the first turning north-east from the first camp and the second turning north at the second camp along the track from Quartz Ridge to the Nile. Naturally it would have been possible for people to turn northwards at any point along the track between Quartz Ridge and the Nile, but it is likely that they would have preferred to do so at relatively significant and well-marked locations. The camps, with their attendant cairns and other features, would have made suitable locations. A route north-east from the first camp east of Quartz Ridge is also supported by the presence of a large gneiss fragment found to the north-east of the camp and cairns on an extension of the route towards Khufu Stela quarry.

Given the few significant landforms around Stelae Ridge and the length of Twenty Cairn Ridge, almost anyone heading north or north-east to Stelae Ridge from the route between Quartz Ridge and the Nile would have needed to cross it and probably used it as a landmark. This conclusion is supported by the consistently good visibility of the cairns on Stelae Ridge from almost the entire length of Twenty Cairn Ridge (Fig 6.7). Travellers heading from Stelae Ridge towards the western part of Twenty Cairn Ridge on their way to Quartz Ridge may have been aided by the distinctive notch in the centre of the ridge, which is clearly visible from Stelae Ridge (Fig 6.8).[283] By aiming west of the notch the travellers would be heading towards Quartz Ridge. By aiming east towards the location Engelbach gave for 20 cairn hill, they would be heading for the Gebel el-Asr and the track back to the Nile.

Fig 6.9 shows the projective and reflective viewsheds for the point in the ‘notch’ of Twenty Cairn Ridge. It reveals that a wide area to the north and south of it would have been inter-visible with the notch, including Stelae Ridge, the Gebel el-Asr, sections of the track between Quartz Ridge and the Nile and multiple locations between Twenty Cairn Ridge and that track. The high points east and west of the notch could have provided even greater visibility and Twenty Cairn Ridge would have made an ideal intermediate landmark between Stelae Ridge and points further south.

[283] See Chapter 3, section 3.7.3 for photographs and discussion of the distinctive appearance of Twenty Cairn Ridge.

Fig 6.8: Photograph taken from Stelae Ridge showing the distinctive notched appearance of the western part of Twenty Cairn Ridge (Author photograph).

There is one further alternative route from Stelae Ridge to Quartz Ridge. Individuals to the west of the mining area may have gone south-west towards Quartz Ridge, without crossing Twenty Cairn Ridge. Almost midway between Stelae Ridge and Quartz Ridge is a landform described by Engelbach as ‘Quartz Hill’. Although it is not classified as inter-visible with Stelae Ridge in the visibility analysis, an area just 820m to the east is inter-visible with Stelae Ridge (Fig 6.7 and Fig 6.10). The SRTM gives this area almost the same height as Engelbach’s Quartz Hill at 219m. Given the error in georeferencing Engelbach’s sketch plan of the quarries, it is possible that Quartz Hill was located at this point, in the area inter-visible with Stelae Ridge and 820m east of the position given on the georeferenced plan.

Fig 6.10 shows the projective and reflective visibility analysis of Quartz Hill. Although Quartz Hill is inter-visible with Quartz Ridge, Fig 6.10 confirms that Quartz Hill as identified by Engelbach would not have been visible from Stelae Ridge or had a view of it. However, the area 820m to the east of Quartz Hill, which was inter-visible with Stelae Ridge in Fig 6.7, is also inter-visible with Quartz Hill in Fig 6.10 and therefore either is Quartz Hill or could have made a suitable intermediate landmark on a route from Stelae Ridge to Quartz Hill to Quartz Ridge.

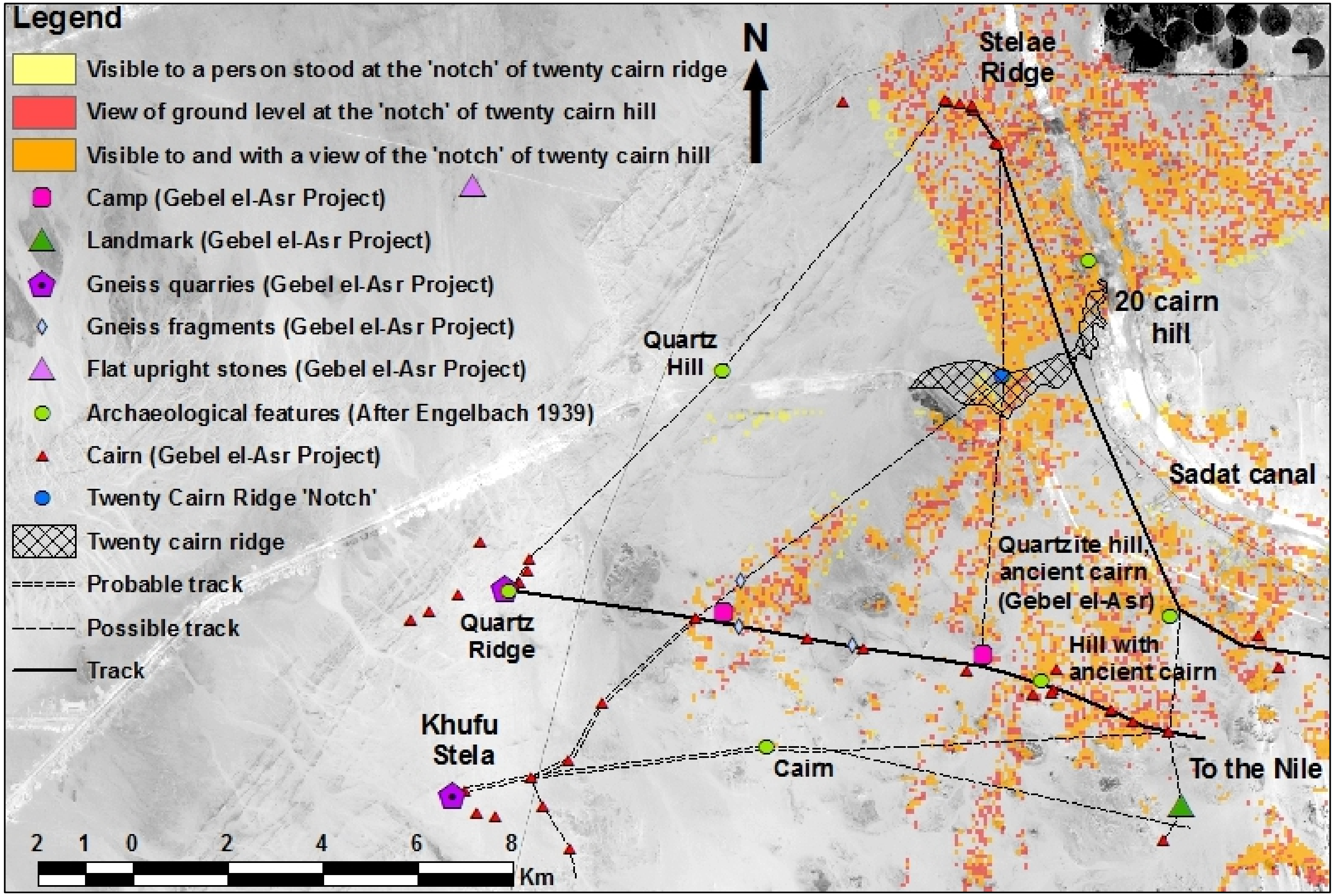


Fig 6.9: Projective and reflective viewsheds for the 'notch' of Twenty Cairn Hill, showing where it was visible and what was visible from it, overlying Landsat 8, panchromatic band (8) from 2013. (Satellite imagery from USGS).

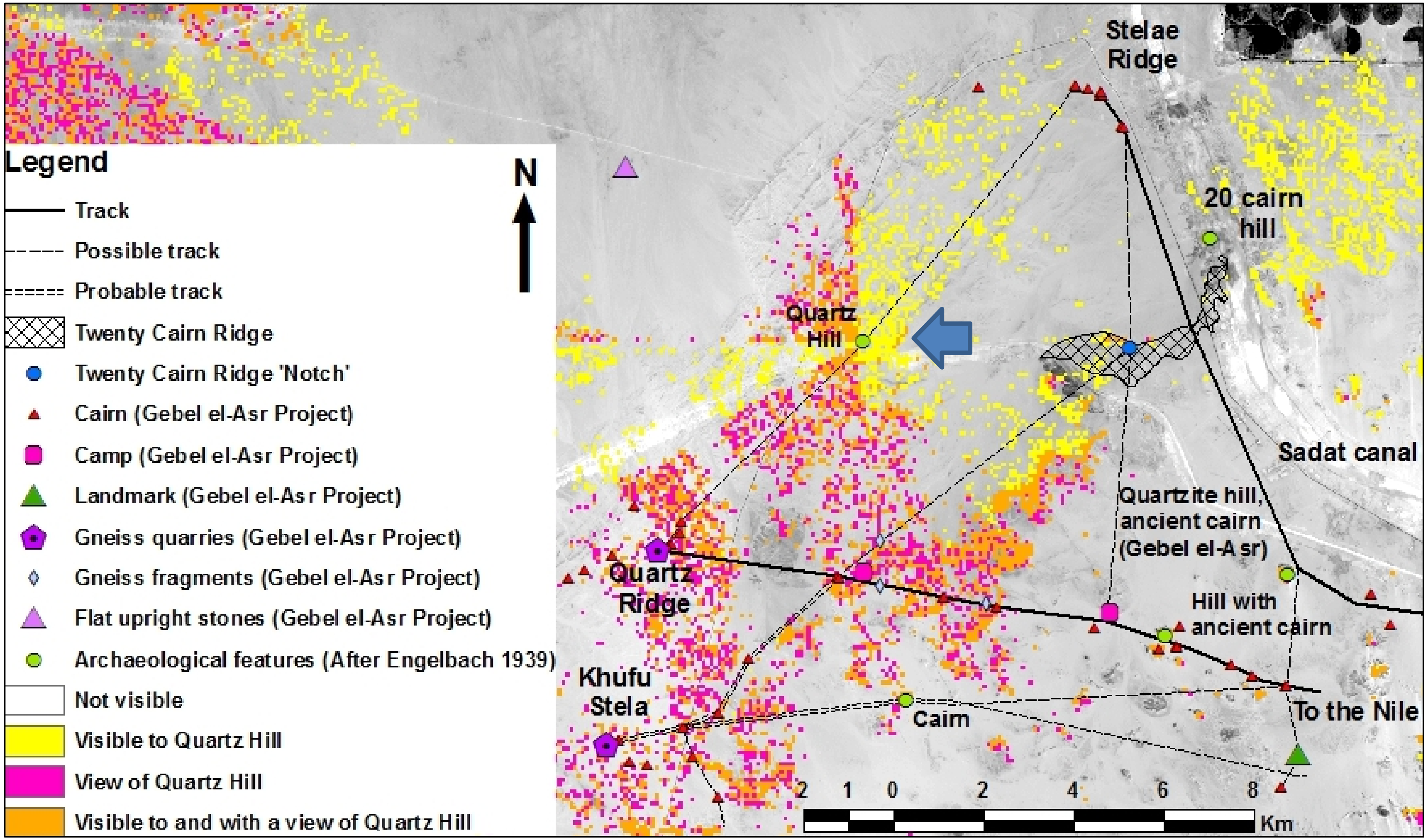


Fig 6.10: Projective and reflective viewsheds for Quartz Hill, showing where it was visible and what was visible from it, overlying Landsat 8, panchromatic band (8) from 2013. Note the small area of orange to the east of Quartz Ridge (marked with the blue arrow) which Fig 6.7 shows is inter-visible with Stelae Ridge. (Satellite imagery from USGS).

Unexplained features

Almost due north of Quartz Ridge and Khufu Stela is a curious archaeological feature, marked by a purple triangle on Fig 6.6 and Fig 6.7. Here the Gebel el-Asr Project recorded several flat stones set up vertically, like blank stelae (Fig 6.11).[284] These features are similar to the Hatnub and Serabit el-Khadim orthostats, allowing for the differences in the stone, but they are some distance from the other archaeological remains and their purpose and date remain a mystery.

Fig 6.11: Two upright stones, set up to the west of the Gebel el-Asr quarries. (Photo courtesy of Ian Shaw).

On the Landsat 8 image the upright stones are located beside a faint white line orientated west-north-west away from the Gebel el-Asr quarries, which is probably a track.[285] The upright stones could therefore be *alamat*, set up in a row to show the route along the track, similar to some types of *alamat* along the Abu Ballas trail (Riemer 2013).

Fig 6.7, Fig 6.9 and Fig 6.10 show the upright stones are not inter-visible with Stelae Ridge, the notch of Twenty Cairn Hill or Quartz Hill. Their presence may indicate that the activity at Gebel el-Asr extended further west than was previously thought. Alternatively they may be of an earlier, or probably less likely, later date. Superficially there are some similarities between the upright stones and the structures of the Neolithic complex at Nabta Playa,[286] and since there is evidence of contact between Gebel el-Asr and Nabta in the Neolithic period, some

[284] Ian Shaw pers comm.
[285] For the appearance of tracks on modern satellite imagery see Bubenzer and Bolton (2013).
[286] For the Neolithic complex at Nabta Playa see Wendorf *et al.* (1996). For the full excavation report of the megalithic alignments and possible solar calendar see Wendorf *et al.* (2001, 463–467 and 489–502).

relationship between these features is possible.[287] However, a certain attribution must await further investigation and additional evidence.

Darb el-Arba'in

There is one further possible route which is worth considering in the context of the visibility analysis of Stelae Ridge. The Darb el-Arba'in is a historic camel route between Darfur and Egypt, which followed the wells of the western desert.[288] A section of this road, between the wells of Nakhlai and Dunqul runs north-west to south-east *c.* 10km north-west of Stelae Ridge, and is shown on both Engelbach's small scale sketch map of the Gebel el-Asr region and on the Survey of Egypt 1: 500,000 scale map of Aswan from 1944.[289]

Murray (1939) suggested that this road was used in Early Dynastic times and later by Old Kingdom Egyptians on trading expeditions. Given that the climate would have been wetter in the Old Kingdom and perhaps the Middle Kingdom too,[290] making the wells along this road more productive, it is worthwhile considering if there is evidence of any visual relationship between the Stelae Ridge structures and the Darb el-Arba'in.

Fig 6.12 shows the line of the Darb el-Arba'in, taken from the 1944 Survey of Egypt map, in comparison to the area which had visibility of at least one cairn and was visible to at least one court on Stelae Ridge. It is clear that the line of the Darb el-Arba'in was not particularly visible from Stelae Ridge and did not have a very good view of it. The viewsheds in Fig 6.12 cross the Darb el-Arba'in north of Stelae Ridge in the area occupied by the modern Tushka Lakes. It is doubtful whether the original Darb el-Arba'in, running across the desert in the depression now occupied by the lakes, would have been visible, particularly over the 11km distance between where the Darb el-Arba'in intersects the viewsheds and Stelae Ridge.[291]

---

[287] A Gebel el-Asr gneiss vessel was found in a Middle or Late Neolithic burial at Gebel Ramlah, *c.* 25km north-west of Gebel Nabta (Schild and Wendorf 2001a, 16–17).
[288] For a colourful description of this road and its early 20th century history see Murray (1939).
[289] For Engelbach's sketch plan of the Gebel el-Asr region see Chapter 3, section 3.3.1 and 3.9.2. For the Survey of Egypt map see Chapter 4, section 4.4.2 and Fig 4.9.
[290] For the climate in the Old and Middle Kingdom see Chapter 4, section 4.4.
[291] For the Tushka Lakes and their impact upon the visibility analysis see Chapter 5, section 5.5.2.

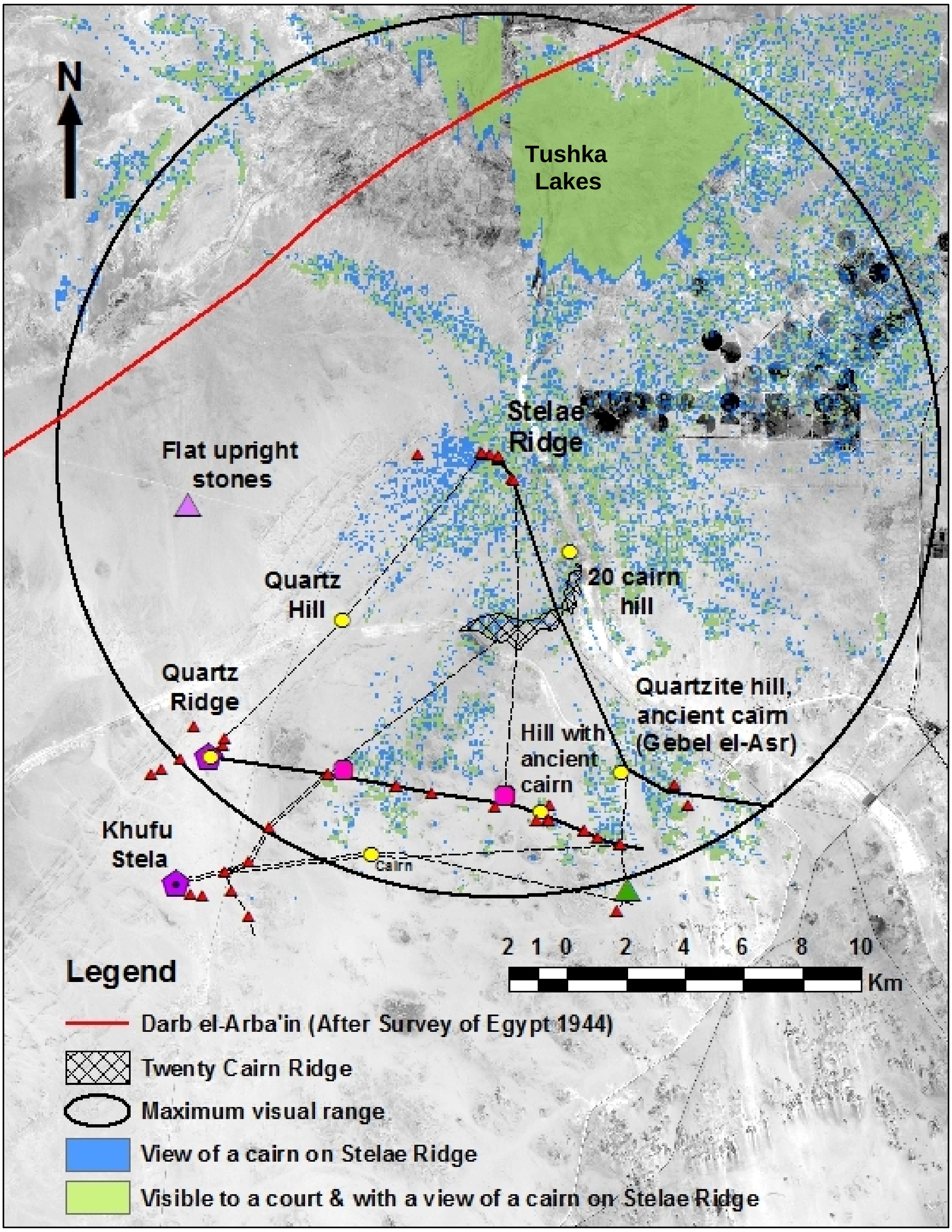


Fig 6.12: The total area visible to any of the courts (green) and the total area from which any of the cairns were visible (blue and green) in relation to the Darb el-Arba'in and archaeological features shown on previous figures, shown overlying Landsat 8, panchromatic band (Band 8) from 2013. (Satellite imagery from USGS).

The only other area where the Darb el-Arba’in runs close to the viewsheds is 10km north-west of Stelae Ridge. Based on the visibility analysis, this is the most likely place for any travellers on the Darb el-Arba’in to have turned south-east towards Stelae Ridge, along a low ridge with good visibility of the site. Alternatively, they may have turned east towards the Gebel el-Asr quarrying region further south-west along the Darb el-Arba’in and used the flat upright stones as an intermediate landmark, assuming that these structures were present.[292] Since the flat upright stones are not visible from Stelae Ridge or Quartz Hill, travellers passing them would have needed to use several intermediate landmarks.

Overall, there is no clear evidence of any substantial visual relationship between the Darb el-Arba’in and Stelae Ridge and therefore the visibility analysis provides no evidence in favour of use of this road by Middle Kingdom travellers to Stelae Ridge. This does not preclude Pharaonic or even Middle Kingdom use of the Darb el-Arba’in, but if it was used travellers on it must have made use of intermediate landmarks if they wished to reach Stelae Ridge. The analysis is clear that the Darb el-Arba’in had no relationship with the visibility of the Stelae Ridge structures and is very unlikely to have influenced their location.

6.1.3. Conclusion

The good visibility of and views from the Stelae Ridge cairn-courts revealed by the systematic visibility analysis and the visual relationships between them and the other areas of Middle Kingdom activity to the south, confirms that Engelbach (1933, 68) was correct to conclude that the structures functioned as landmarks and reveals more about the landscape of the quarry area and the role of the cairn-courts. Combining evidence from the visibility analysis with archaeological data recorded by Engelbach (1933; 1939) and the Gebel el-Asr Project, has contributed a probable resolution to the problem of 20 cairn hill and Twenty Cairn Ridge. Stelae Ridge was not inter-visible with Quartz Ridge and Khufu Stela quarry, but the visibility analysis of Stelae Ridge combined with new visibility analysis of several intermediate locations revealed how those places formed landmarks for travellers moving through the landscape and, to a certain extent, determined the routes of the tracks that they followed. Visibility analysis has never been used before to locate tracks or roads at either Gebel el-Asr or other Egyptian sites, although other routes have been mapped through traditional archaeological survey.[293] The success here suggests that visibility analysis might

[292] A modern track runs right past the flat upright stones and those using it probably make use of them as landmarks.
[293] For survey of tracks and roads at Egyptian sites see Bard *et al.* (2013); Bubenzer and Bolton (2009); Bülow-Jacobsen (2013); Darnell and Darnell (2013); Förster (2013); Harrell and Brown (1995); Harrell and Storemyr (2009); Heldal (2009); Hendrickx *et al.* (2013); Hoffmeier and Moshier (2013); Kelany *et al.* (2009); Riemer (2013); Riemer and Förster (2013); Rossi and Ikram (2013);

be used elsewhere, particularly where sections of roads have been destroyed by modern activity.

6.2. The visibility analysis of Stelae Ridge in its landscape context

The preceding sections of this chapter have shown how the structures on Stelae Ridge were visually connected with significant topographic features on tracks leading to other sites of Middle Kingdom activity across the Gebel el-Asr quarries, demonstrating how visibility helped to form and connect routes between places that were not naturally inter-visible with each other. In this section the differences between the structures on Stelae Ridge are considered.

6.2.1. Differences between Stelae Ridge south and Stelae Ridge north

The eight cairns on Stelae Ridge were divided between two ridges, Stelae Ridge south and Stelae Ridge north (Fig 6.13). The systematic visibility analysis presented in Chapter 5 showed that the structures on Stelae Ridge south were much more visible and had a better view than those on Stelae Ridge north. The structures on Stelae Ridge north were less visible and had less extensive views.

The practical effects of these differences are clear in Fig 6.14–Fig 6.17. The cairns on Stelae Ridge north were much less visible to the south and east of the site, where the Gebel el-Asr quarries were located (Fig 6.17). The view of the quarries and the tracks was also very limited from the courts on the northern ridge (Fig 6.16). Conversely, the cairn-courts on Stelae Ridge south had a very good view of the landscape and were highly visible from the many topographic and archaeological features along the tracks within the quarries (Fig 6.14–Fig 6.15). The Stelae Ridge south structures would therefore have been much better suited to a role as landmarks. The cairn-courts on Stelae Ridge north would not have been as effective as landmarks, since they had smaller viewsheds and were not particularly visible from the Gebel el-Asr quarries to the south.

Snape (2013); Somaglino and Tallet (2013); Storemyr *et al.* (2013); The quarry road and subsidiaries at Hatnub are published in Shaw (2010, 109–114; 2013). The paths within the Hatnub settlement have not been surveyed and published but were visible to the author during visits to the site. This raises the question of whether similar features are present at other mining or quarrying sites, but are not typically recorded.

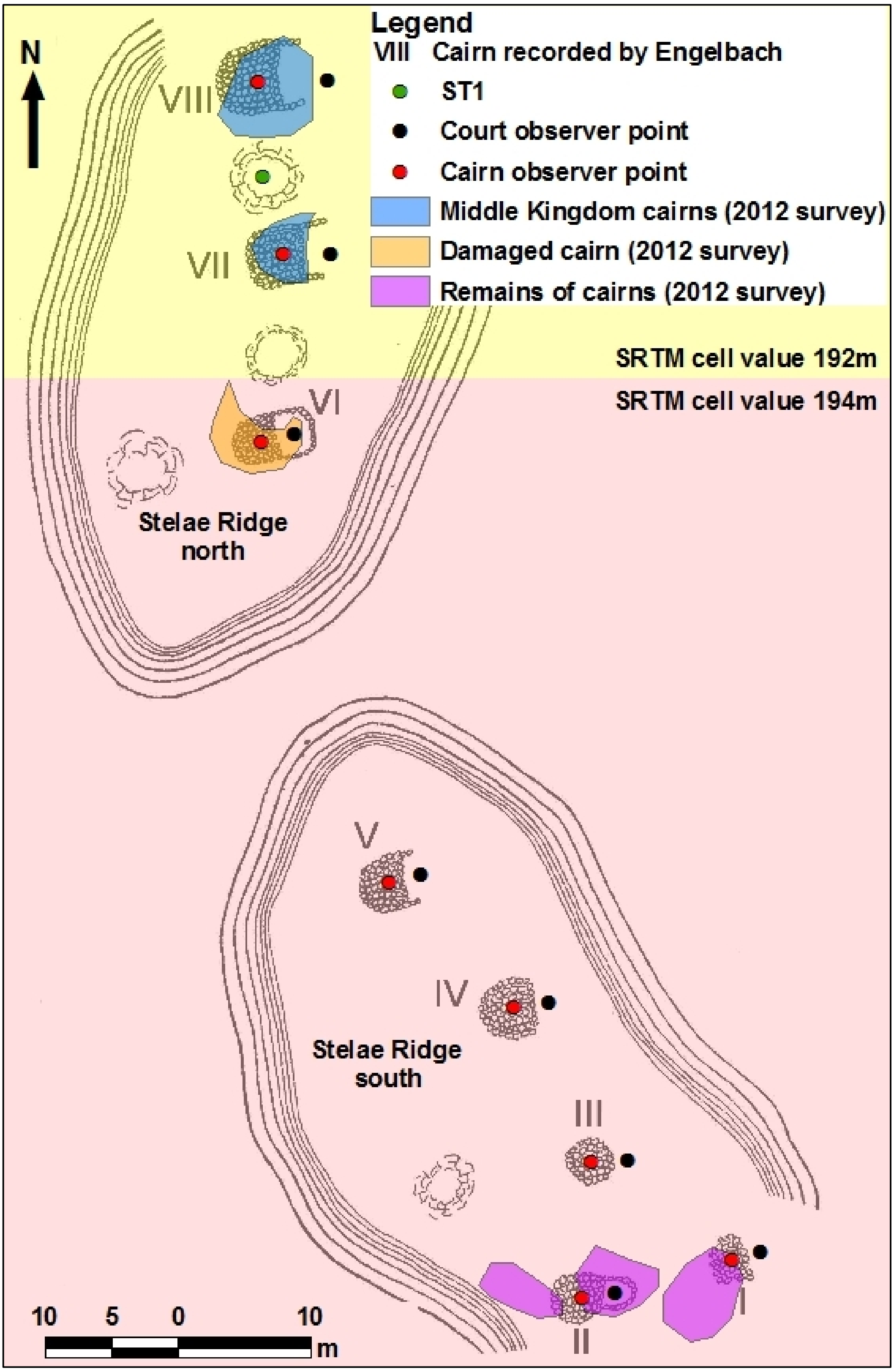


Fig 6.13: Stelae Ridge, showing the two ridges on Engelbach's sketch plan, the cairns and remains of cairns surveyed in 2012 and the observer locations for the visibility analysis of the courts (black) and cairns (red) overlaid on the SRTM cells. SRTM tile n22_e031_3arc_v2 (SRTM data from the USGS)

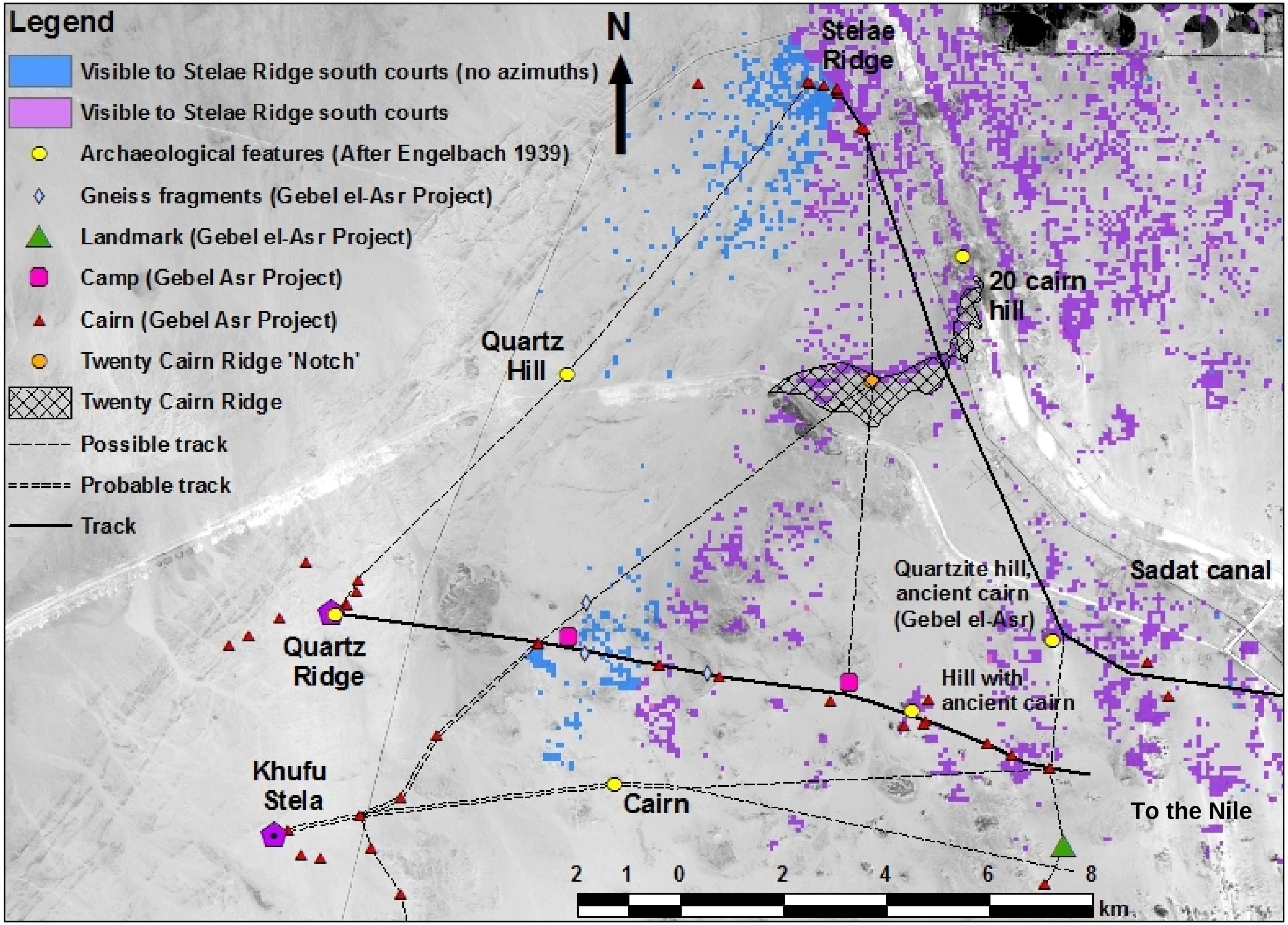


Fig 6.14: Detail of the projective viewshed showing the topographic and archaeological features visible to all the courts on Stelae Ridge south with and without azimuths. The viewshed and features are shown overlying Landsat 8, panchromatic band (8) from 2013. (Satellite imagery from USGS).

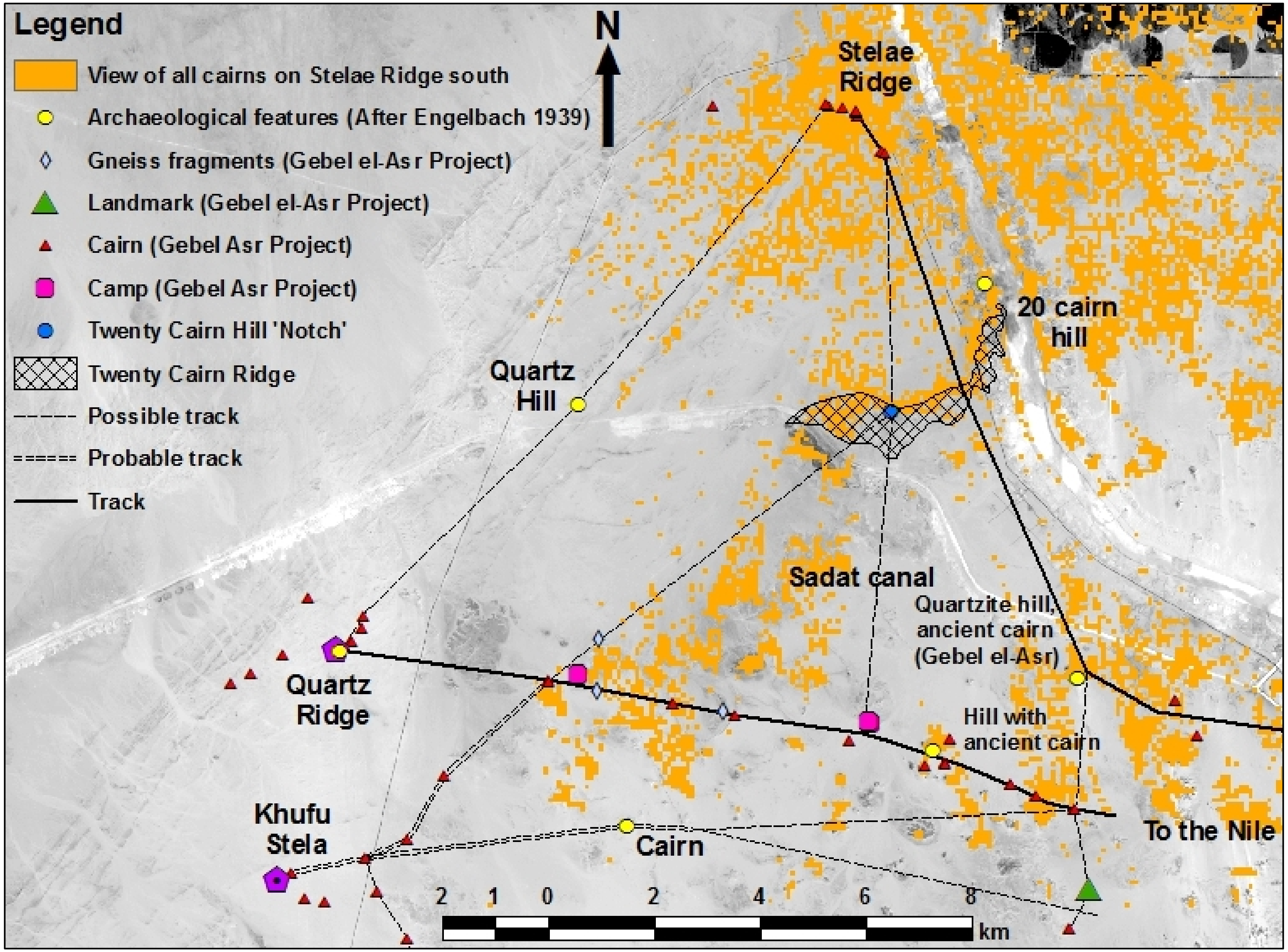


Fig 6.15: Detail of the reflective viewshed showing the area with a view of all the cairns on Stelae Ridge south, overlying Landsat 8, panchromatic band (8) from 2013. (Satellite imagery from USGS).

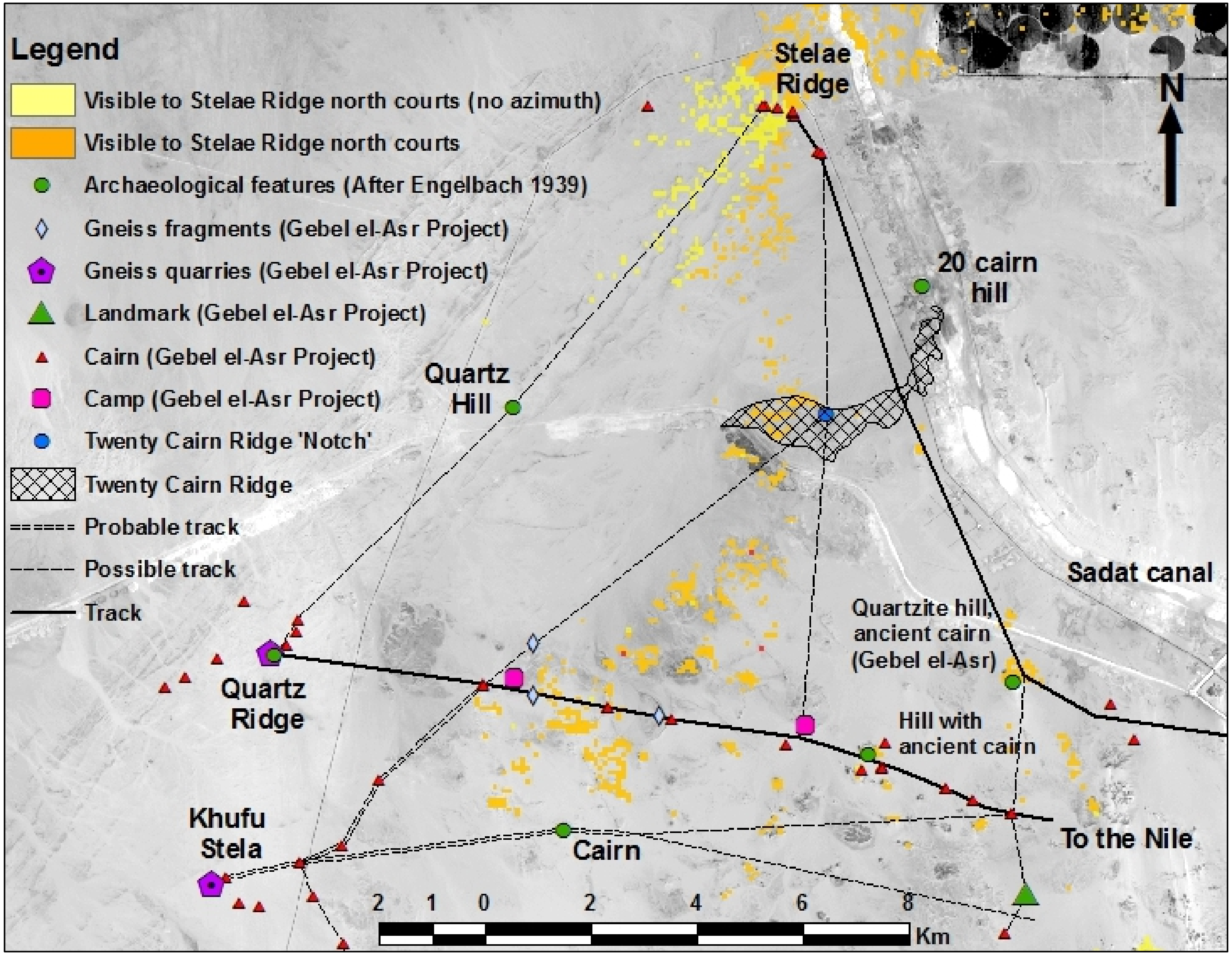


Fig 6.16: Detail of the projective viewshed showing the area visible to all the courts on Stelae Ridge north, with and without azimuths, depicted overlying Landsat 8, panchromatic band (8) from 2013. (Satellite imagery from USGS).

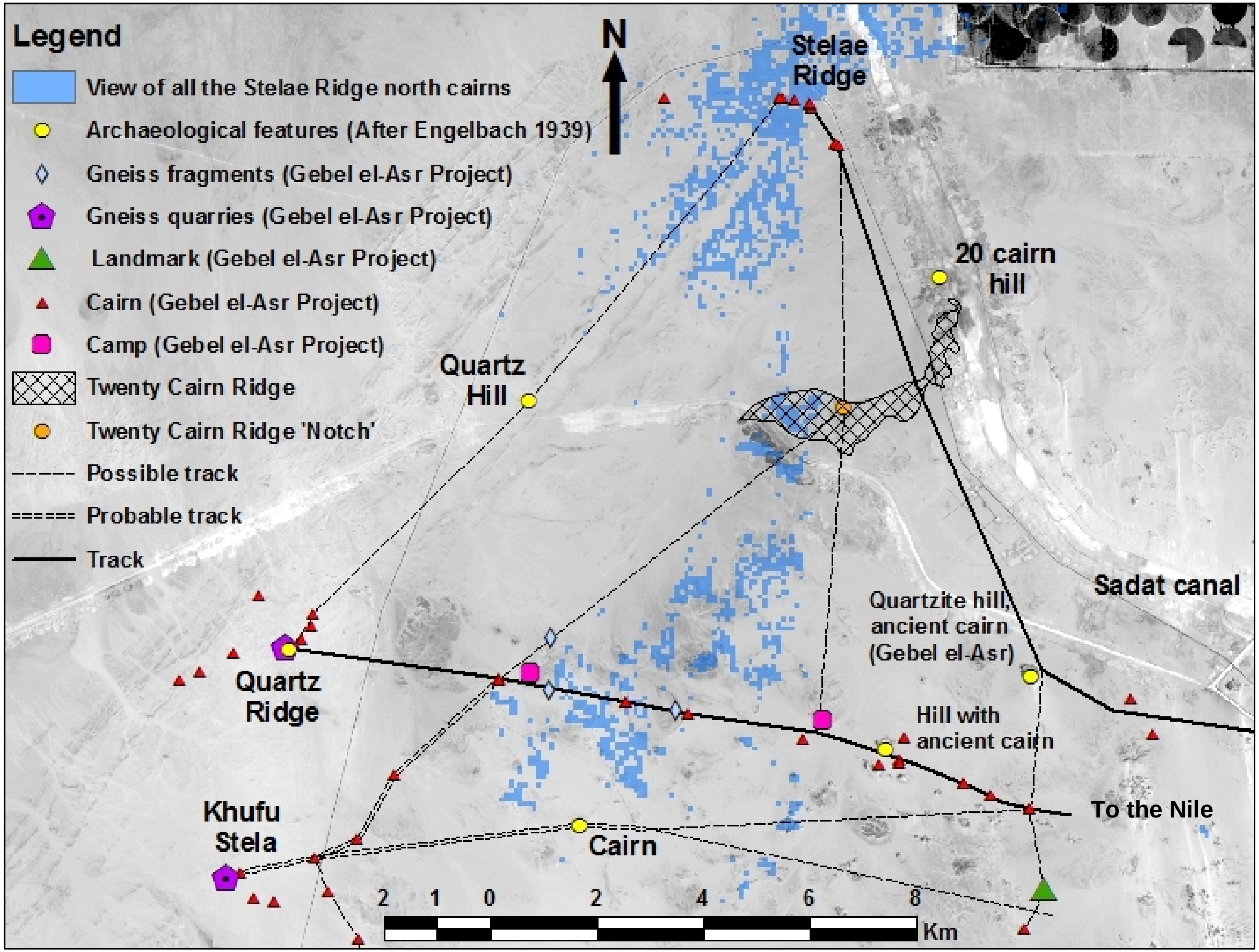


Fig 6.17: Detail of the reflective viewshed showing the area where all the cairns on Stelae Ridge north were visible, overlying Landsat 8, panchromatic band (8) from 2013. (Satellite imagery from USGS).

6.2.2. Differences between the visibilities of individual structures

Visibility analysis of the courts indicated that there was no consistent relationship between viewshed size or appearance and courts with the same artefacts, court structure or dating to the same reign.[294] However there were differences between the viewsheds of individual structures, particularly those on Stelae Ridge north.

The subtle differences in viewshed size between the individual structures on Stelae Ridge south were probably not visually perceptible to their builders. However they are associated with each structure's position on the ridge, which reflects a conscious choice made by its builders.[295] Since the position of a structure will be partly determined by the availability of space and therefore the presence of other structures on the ridge, subtle differences in viewshed size may reflect the chronological development of the structures, even when their builders were unaware of the direct implications for visibility.

Table 6.1 shows the ranking of the cairn-courts by viewshed-size from largest to smallest, based on the various visibility analyses undertaken in Chapter 5, section 5.1, 5.2, 5.3 and 5.4.1.[296] The results of the visibility analyses of the courts without azimuths and of ground level at the cairns have been included in the table because they provide useful controls for the parameters used in the other visibility analyses. However, the projective visibility analysis of the courts with and without azimuths and the reflective visibility of the cairns are most relevant to the subsequent discussions and will be shown in detail in the accompanying figures.[297]

---

[294] For the results of the visibility analysis of the courts by reign see Chapter 5, section 5.1.2.
[295] Tests described in Chapter 5, section 5.4.1 and 5.4.3 revealed that despite the low resolution of the SRTM, the visibility analysis based upon it did reveal differences that could be related to the different positions of the structures on the ridges.
[296] The reflective visibility analysis of the courts with and without azimuths are not included, because the cairns are much more visible than the courts.
[297] Viewsheds produced by the other visibility analyses are presented in the relevant sections in Chapter 5.

Table 6.1: Comparison of the ranking of the Stelae Ridge structures by viewshed size. The largest viewshed for each analysis is represented by 1, the smallest by 8.

	Projective		Reflective	
Cairn-court	Court with azimuths	Court without azimuths	Cairn	Ground level at the cairns
I	4	3	4	4
II	3	5	5	5
III	1	4	3	3
IV	5	1	2	1
V	2	2	1	1
VI	6	6	6	7
VII	8	8	8	8
VIII	7	7	7	6

6.3. Chronological development of Stelae Ridge.

The differences between the visibilities of individual structures reveal more about the chronological development of the site, particularly in the context of the differences in visibility between the two ridges and the dates of the dated cairn-courts.[298]

6.3.1. Visibility and the dated cairn-courts

The earliest inscribed artefacts from Stelae Ridge come from Stelae Ridge south (Fig 6.13). Court IV contained the earliest stela, dating to the co-regency of Amenemhat I and Senusret I, together with a second stela dating to year 20 of the sole-rule of Senusret I. This places the construction of cairn-court IV at the beginning of the 12th Dynasty, a period of great expansion when Senusret I is associated with many new inscriptions in ritual settings at mining and quarrying sites.[299] Senusret I undertook a military campaign to the south of Egypt in year 18 and inscriptions from year 20 have been found at the amethyst mine at Wadi el-Hudi, south-east of Aswan on the opposite side of the Nile from Stelae Ridge, suggesting renewed mining operations at Wadi el-Hudi in that year.[300] It is reasonable to conclude that Senusret I re-opened the mines or ordered new expeditions to both Wadi el-

[298] Based on the evidence presented in Chapter 3, section 3.2.3 the cairn-courts are assumed to be the same date as the artefacts found within them.
[299] For evidence of the expansions in mining under Senusret I see Sadek (1980, 23) and Simpson (1958, 309). Valbelle and Bonnet (1996, 80–82) attribute the earliest phases of the temple at Serabit el-Khadim to Senusret I.
[300] For the evidence from Wadi el-Hudi see Sadek (1980).

Hudi and Stelae Ridge in year 20, commemorating this act with a new stela in court IV at Stelae Ridge.

Court IV has the largest projective viewshed without azimuths (Fig 6.18),[301] indicating that it had the best view of any of the courts on Stelae Ridge south before the cairn was constructed. Cairn IV has the second largest reflective viewshed (Fig 6.19) and prior to construction of the cairn its position had the joint largest reflective viewshed, indicating how visible it was from the landscape (Table 6.1). The relatively high rank of cairn-court IV when the cairn-courts are ordered by viewshed size, reflects its central position on Stelae Ridge south (Fig 6.13), which would only be available to a structure built relatively early in the sequence. Like all the structures on Stelae Ridge south cairn-court IV was particularly visible to the south and south-east and had a good view of the same area, including significant elements of Twenty Cairn Ridge and various other areas along the tracks across the quarries. This would have made it a valuable landmark, in addition to its commemorative or ritual aspects.

Court VI is dated to the reign of Senusret II and is located at the south end of Stelae Ridge north.[302] It is the earliest structure on Stelae Ridge north since cairn-courts VII and VIII date to Amenemhat III, but the undated structures on Stelae Ridge south could possibly be earlier. Cairn-court VI is not as good a location as cairn-court IV, or anywhere on Stelae Ridge south, in terms of viewshed size. However Table 6.1 shows that it does have the largest projective viewshed of any court on Stelae Ridge north, with or without azimuths, and the largest reflective viewshed of any cairn on Stelae Ridge north,[303] giving it the best visibility on the ridge. Court VI had good views to the south and south-east of Stelae Ridge (Fig 6.20) and cairn VI was visible to many significant locations in the Gebel el-Asr quarries and along the tracks (Fig 6.21).

[301] Due to the long flat face of cairn IV and the correspondingly large angle excluded from the viewsheds by the azimuths, the projective and reflective viewsheds of court IV with azimuths are the lowest on the southern ridge (Chapter 5, section 5.2.2). However, as discussed in Chapter 5, section 5.2.3, this probably exaggerates how limited visibility really was and it may not reflect choices about the location of the cairn-court, made prior to construction of the cairn.
[302] A stela of Amenemhat II, the Pharaoh who reigned between Senusret I and Senusret II, was found at Cairn 013, *c.* 100m west of Stelae Ridge (Chapter 3, section 3.7.2; Shaw 2003, 453). However, this cairn could not be included in the systematic visibility analysis because it had been destroyed and there is no evidence of its original layout. For general visibility of cairn 013 see section 6.5.
[303] Ground level at cairn VI was not as visible as ground level at cairn VIII, but this is largely irrelevant since the cairns were the structures that were intended to be visible, not ground level beneath them.

6.3.2. The reign of Amenemhat III

Cairn-courts I, VII and VIII all date to the reign of Amenemhat III, but their viewsheds are very variable. Court VII has the most restricted projective viewshed (Fig 6.22) and cairn VII the most restricted reflective (Fig 6.23) viewshed of any of the Stelae Ridge structures. Court VIII has the second smallest projective viewshed, with or without azimuths (Fig 6.24), and cairn VIII has the second smallest reflective viewshed (Fig 6.25). Unlike VII and VIII, cairn-court I is located on Stelae Ridge south and has much better visibility. With azimuths, court I has the fourth largest projective and reflective viewshed, and without azimuths it has the third largest (Fig 6.26), while cairn I is the fourth most visible cairn (Fig 6.27). Cairn-court I is also one of two cairn-courts on Stelae Ridge south that only has a pseudo-court.[304] Both have good visibilities, but since the other is cairn-court IV, the earliest dated structure at Stelae Ridge, it seems unlikely that cairn-court I's pseudo-court is associated with its date. The good visibilities of both structures with pseudo-courts is probably more to do with their position on Stelae Ridge south.[305] Overall, the variation between the viewsheds of the structures dated to the reign of Amenemhat III suggests that their location was influenced by a factor other than visibility.

All the cairn-courts dated to Amenemhat III are located on the periphery, either at the northern or southern end of Stelae Ridge. Cairn-court I is at the south end of the southern ridge to the south-east of cairn III, while cairn-court VII and VIII are in a line at the north end of the northern ridge (Fig 6.13). All the cairn-courts associated with Amenemhat III have relatively small viewsheds compared to others on their ridge, confirming the effect of their peripheral location upon visibility. This was probably because by the reign of Amenemhat III, much of the space on Stelae Ridge was already occupied by the other cairn-court structures and either the pits or whatever structures had originally been located where the pits are shown on Fig 6.13.[306] Cairn-courts I, VII and VIII were therefore located wherever there was space, north of cairn-court VI and south of cairn III.

[304] For the pseudo-courts see Chapter 3, section 3.2.4.
[305] For the visibility of the structures with pseudo-courts see Chapter 5, section 5.1.2.
[306] In addition to the eight cairn-courts Engelbach's (1939, pl. LIV) sketch plan of Stelae Ridge (Fig 6.13) shows four pits, three on Stelae Ridge north and one on Stelae Ridge south. Engelbach (1933, 68) speculated that these pits had originally been covered by cairns, pulled down by the Roman robbers who moved some of the artefacts and left Roman pottery. This may be true, but the pits may also have served an alternative purpose. They could have been old carnelian mines or possibly even wells, like those found elsewhere by the Gebel el-Asr Project (Shaw *et al.* 2010, 304).

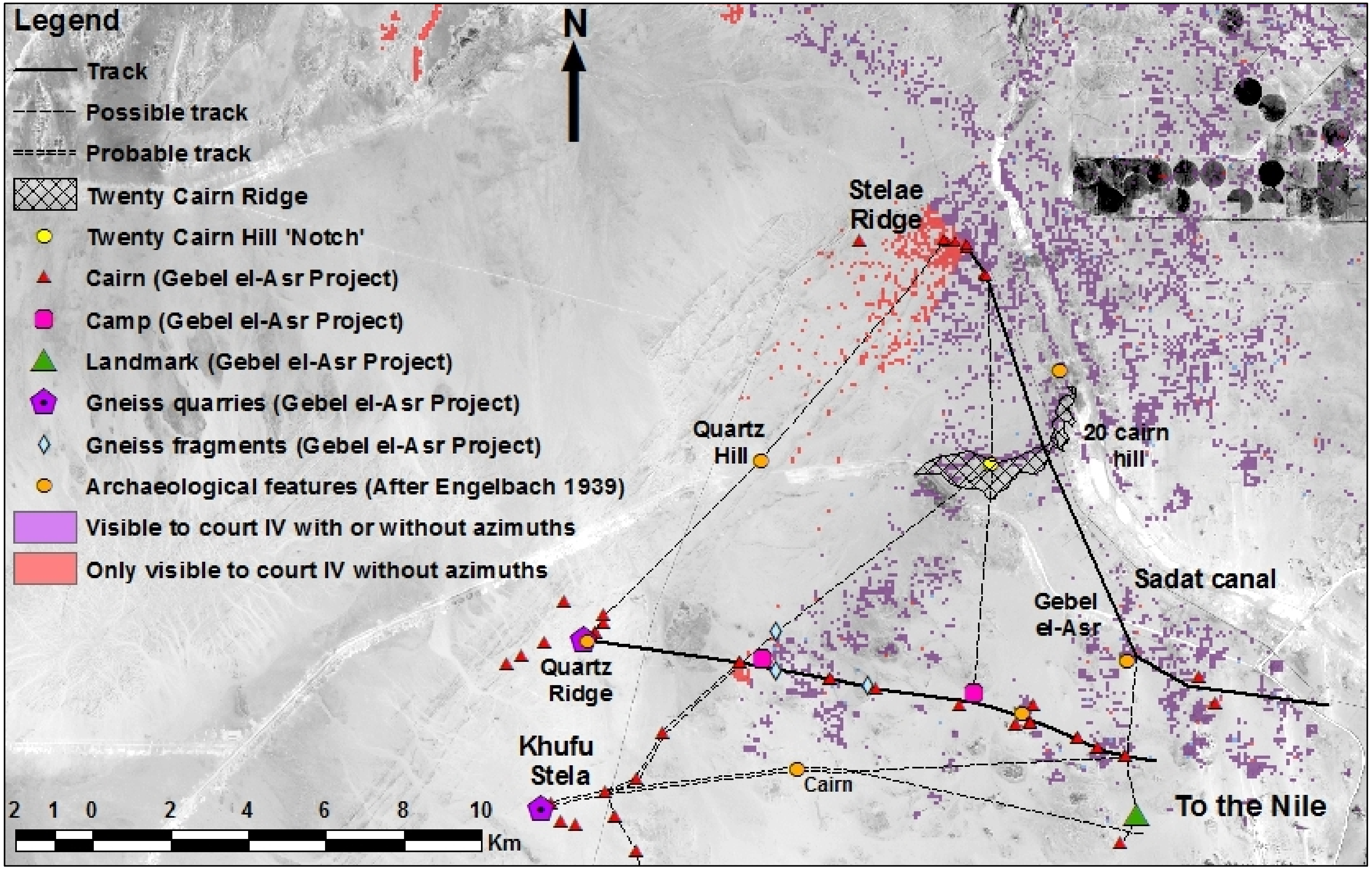


Fig 6.18: The projective viewshed for court IV on Stelae Ridge south, showing what was visible from the court with and without azimuths, overlying the panchromatic band (8) of Landsat 8 imagery from 2013 (Satellite imagery from USGS).

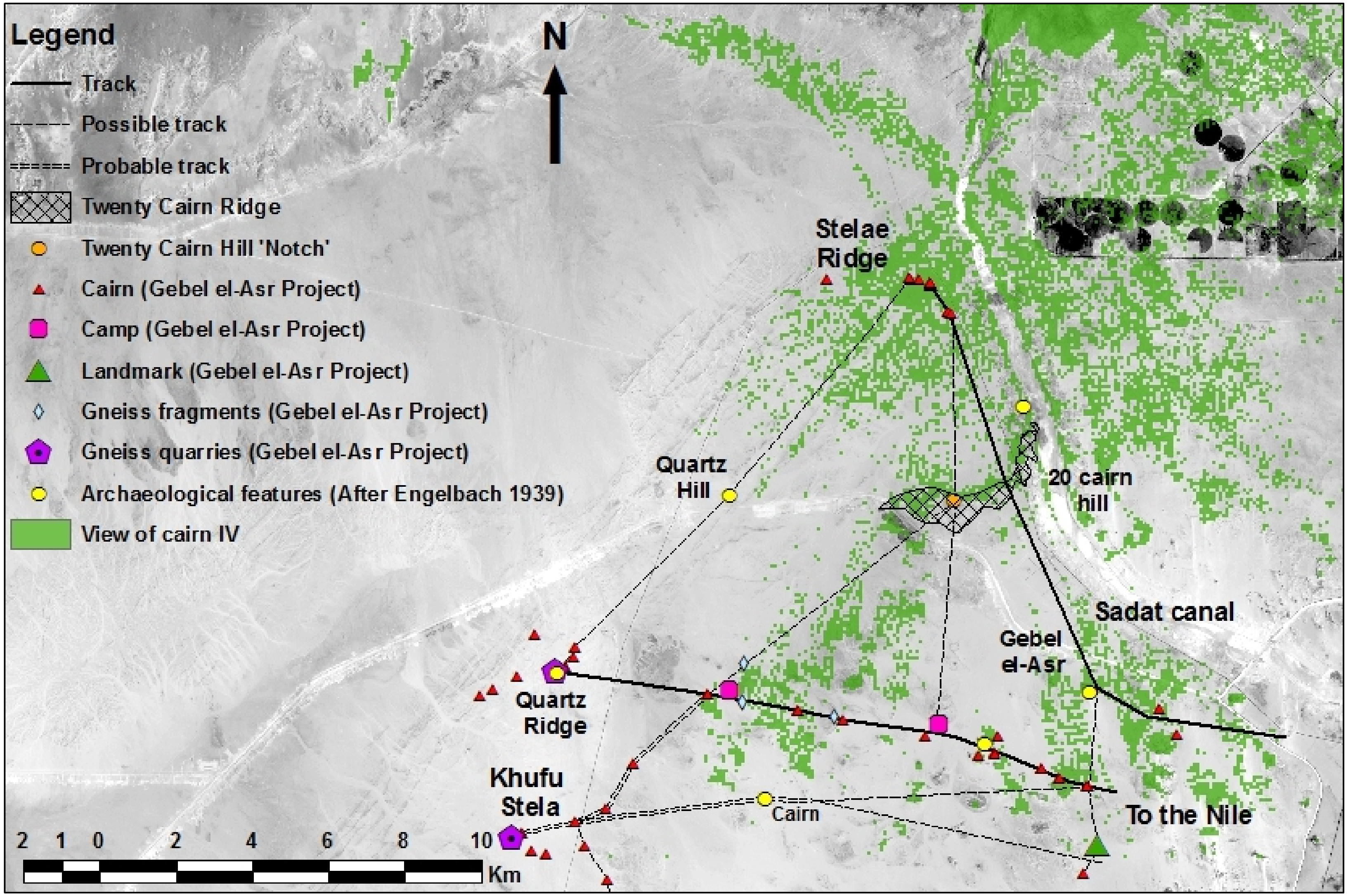


Fig 6.19: The reflective viewshed for cairn IV on Stelae Ridge south, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

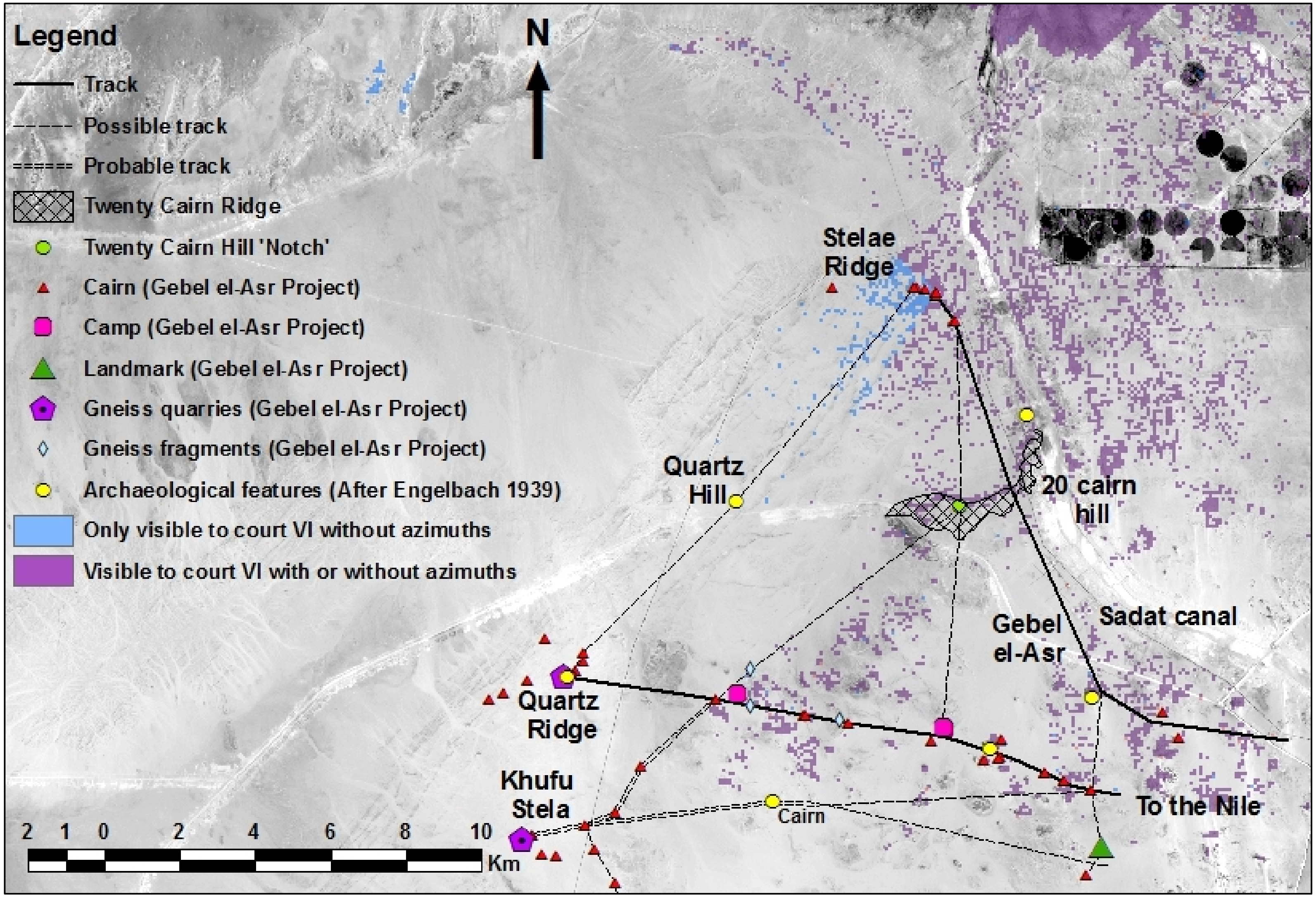


Fig 6.20: The projective viewshed for court VI on Stelae Ridge north, showing what was visible from the court, with and without azimuths, depicted overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

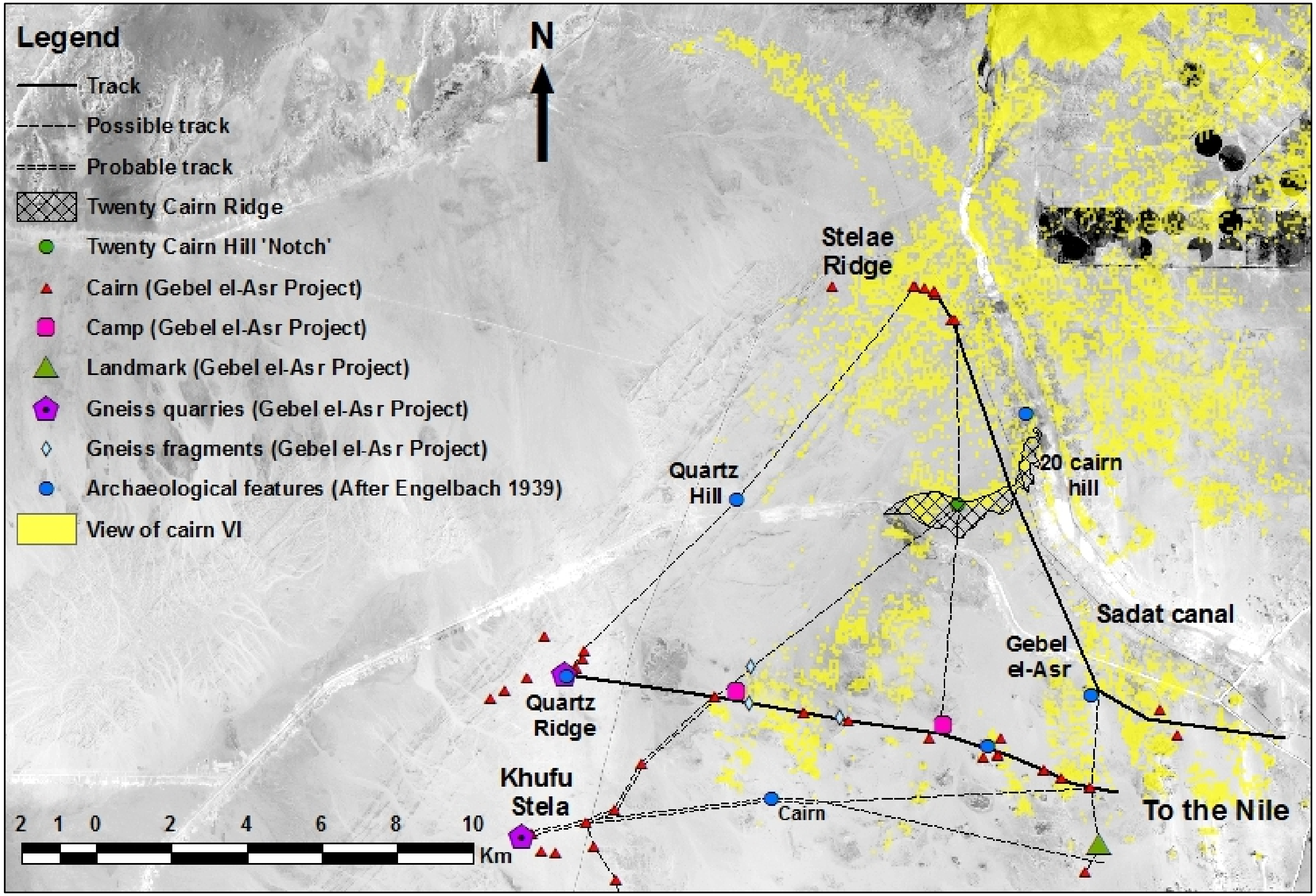


Fig 6.21: The reflective viewshed for cairn VI on Stelae Ridge north, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

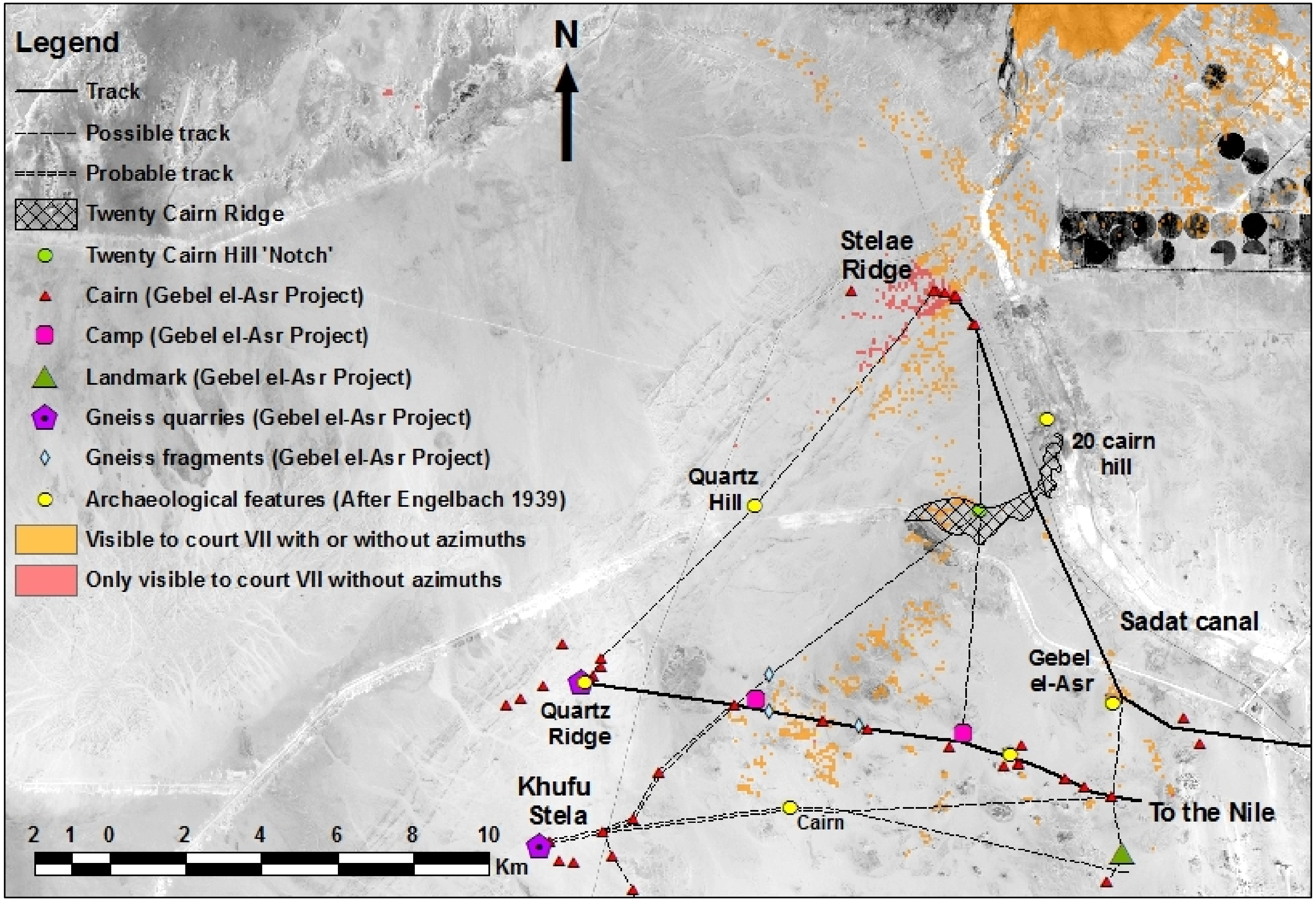


Fig 6.22: The projective viewshed for court VII on Stelae Ridge north, showing what was visible from the court with and without azimuths, shown overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

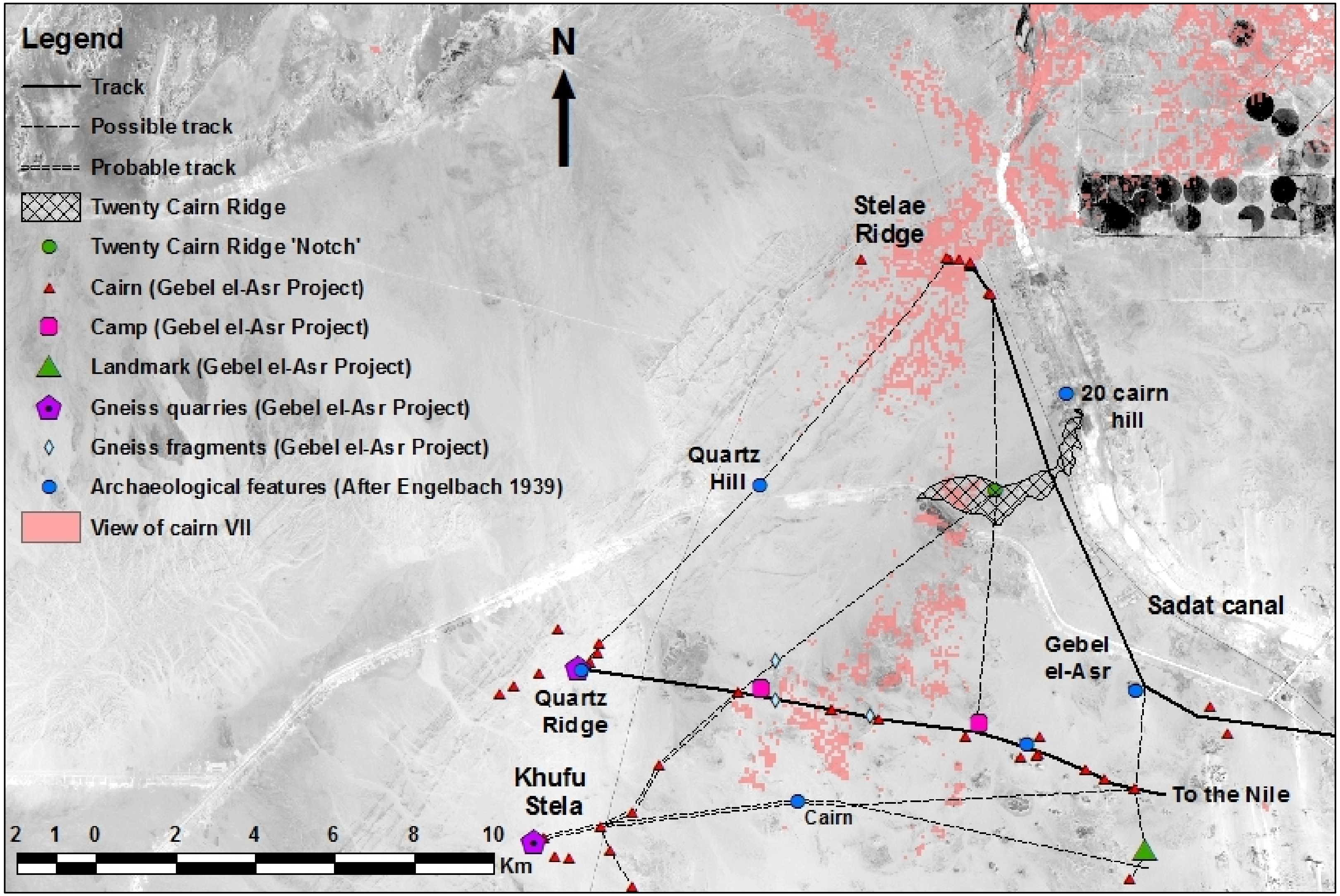


Fig 6.23: The reflective viewshed for cairn VII on Stelae Ridge north, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

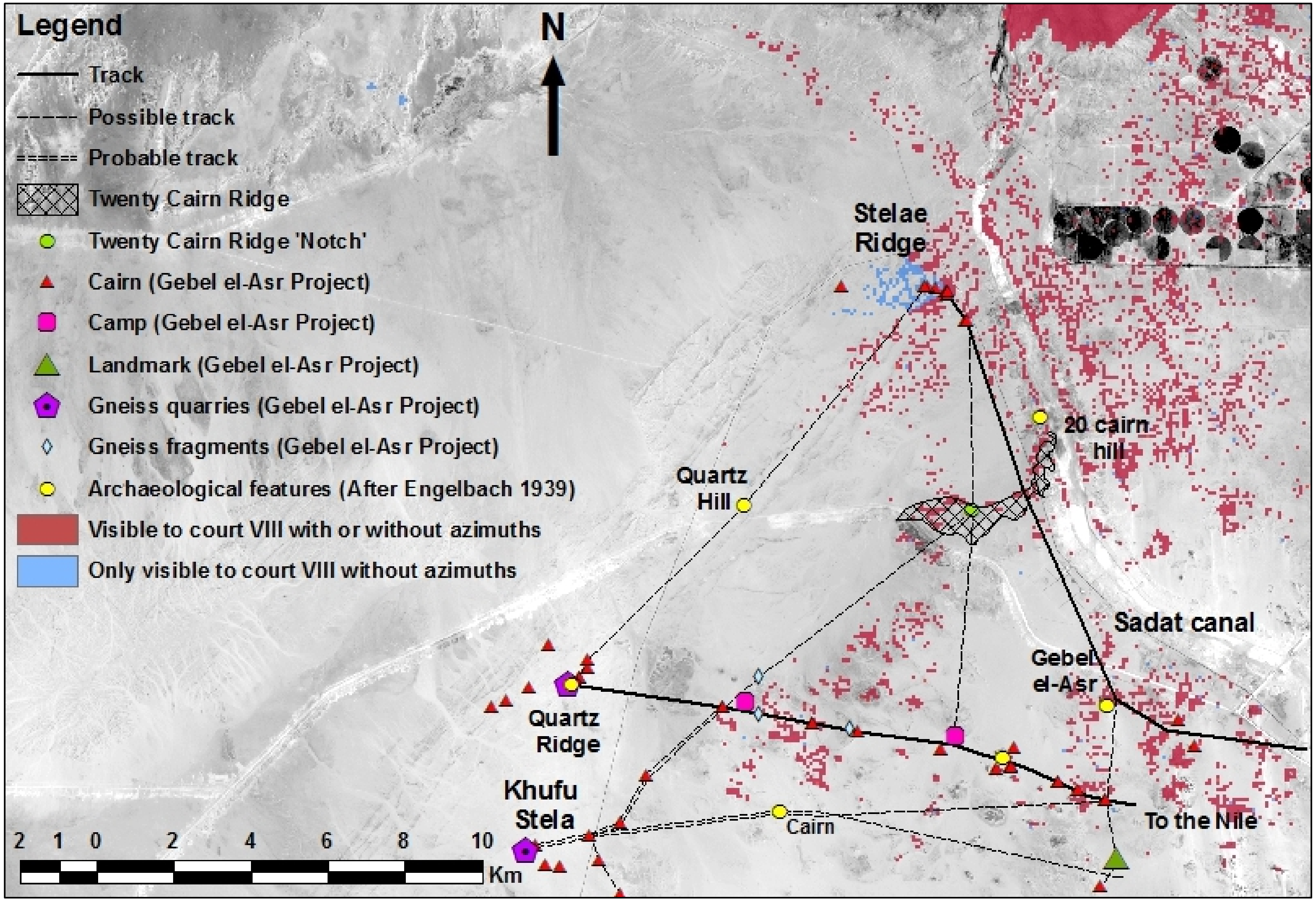


Fig 6.24: The projective viewshed for court VIII on Stelae Ridge north, showing what was visible from the court with and without azimuths, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

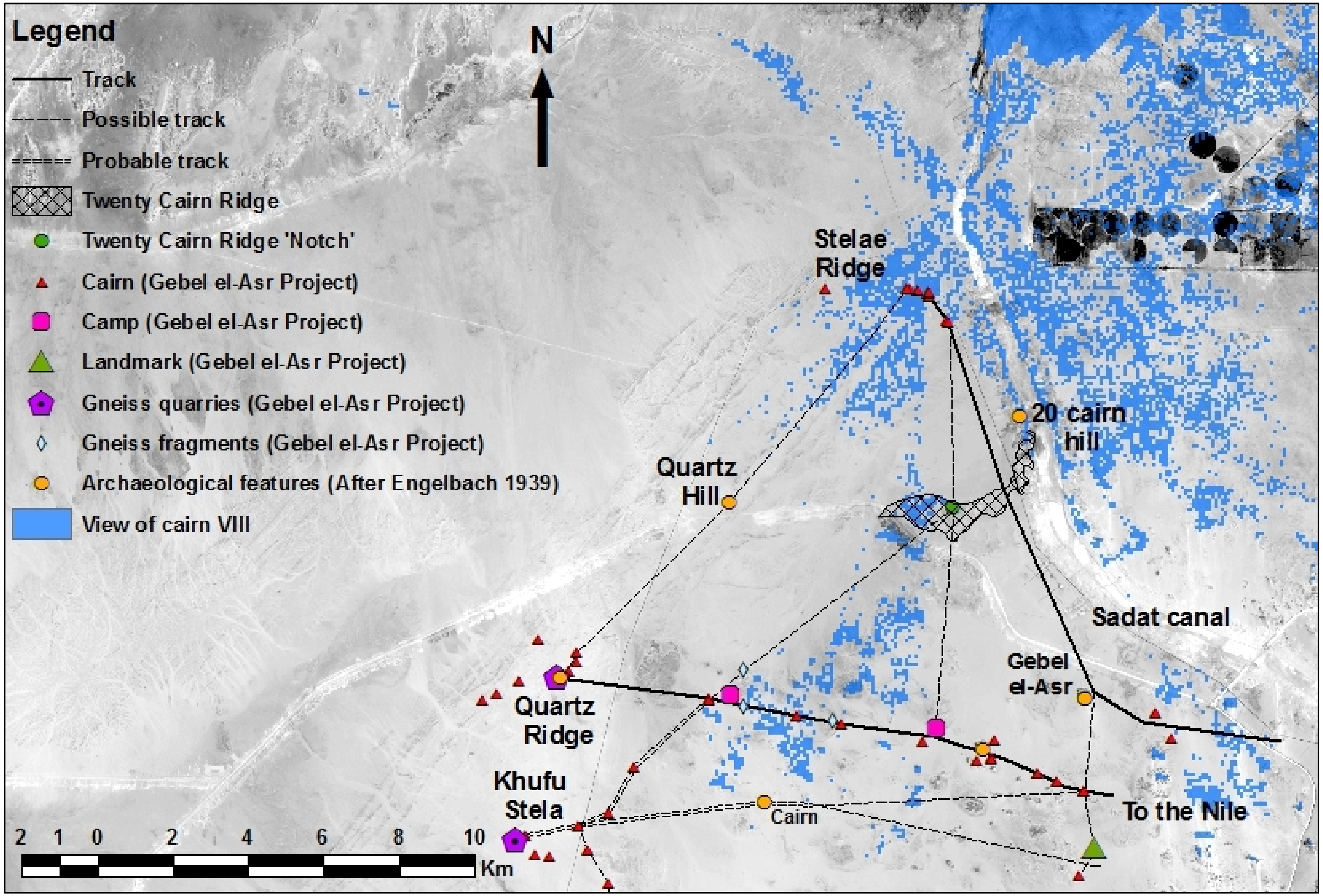


Fig 6.25: The reflective viewshed for cairn VIII on Stelae Ridge north, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

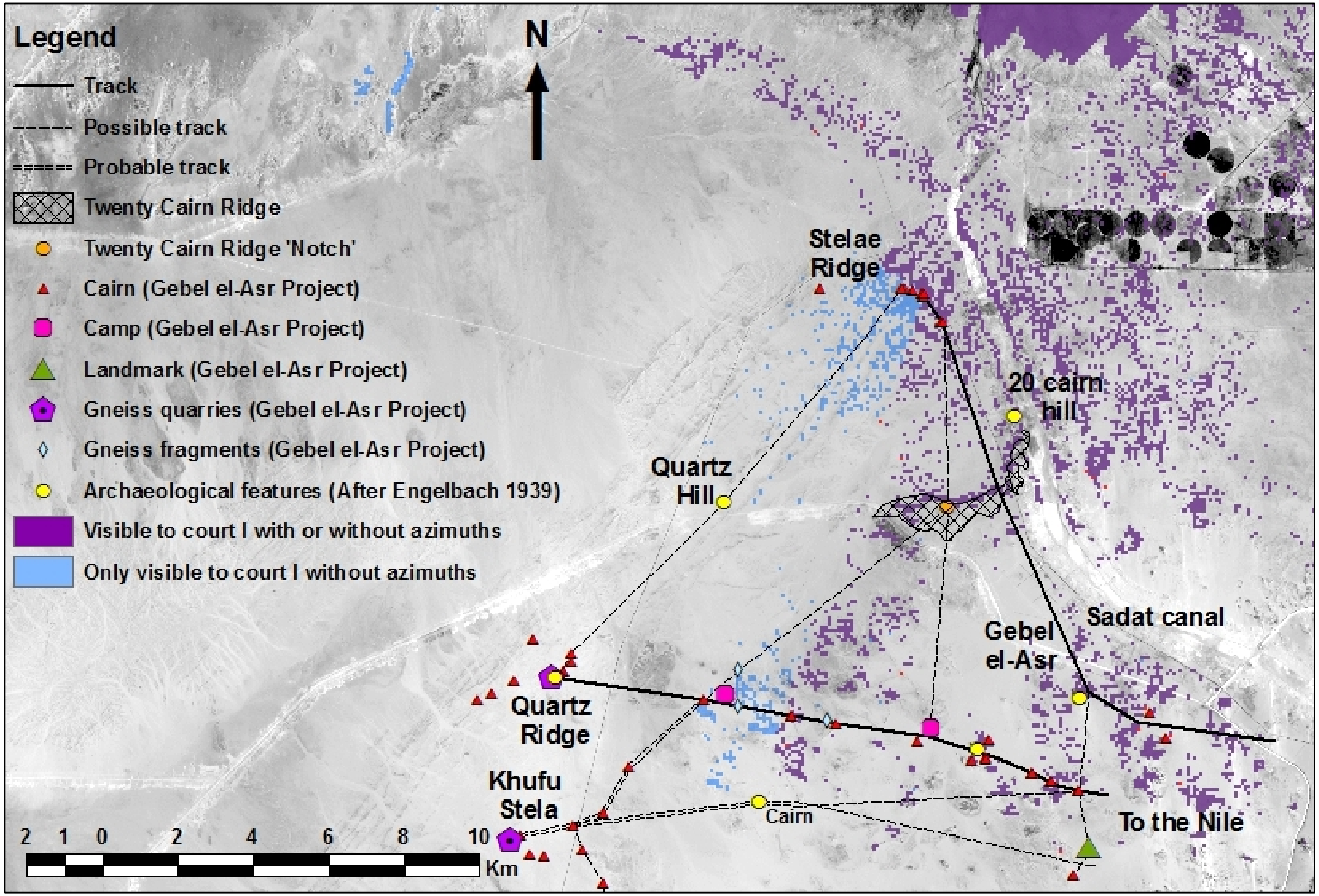


Fig 6.26: The projective viewshed for court I on Stelae Ridge south, showing what was visible from the court with and without azimuths, overlying the panchromatic band (8) of Landsat 8 image from 2013. (Satellite imagery from USGS)

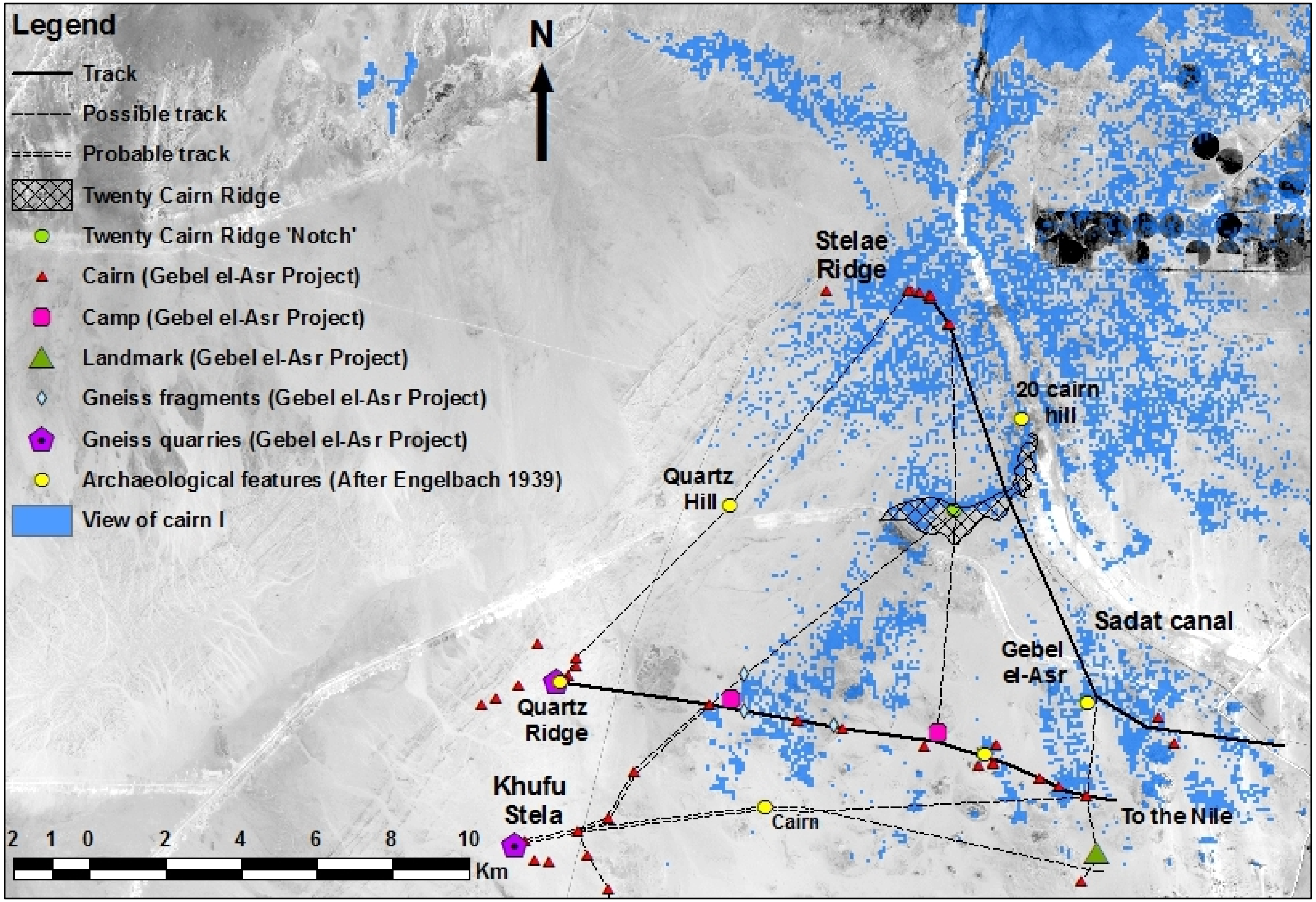


Fig 6.27: The reflective viewshed for cairn I on Stelae Ridge south, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

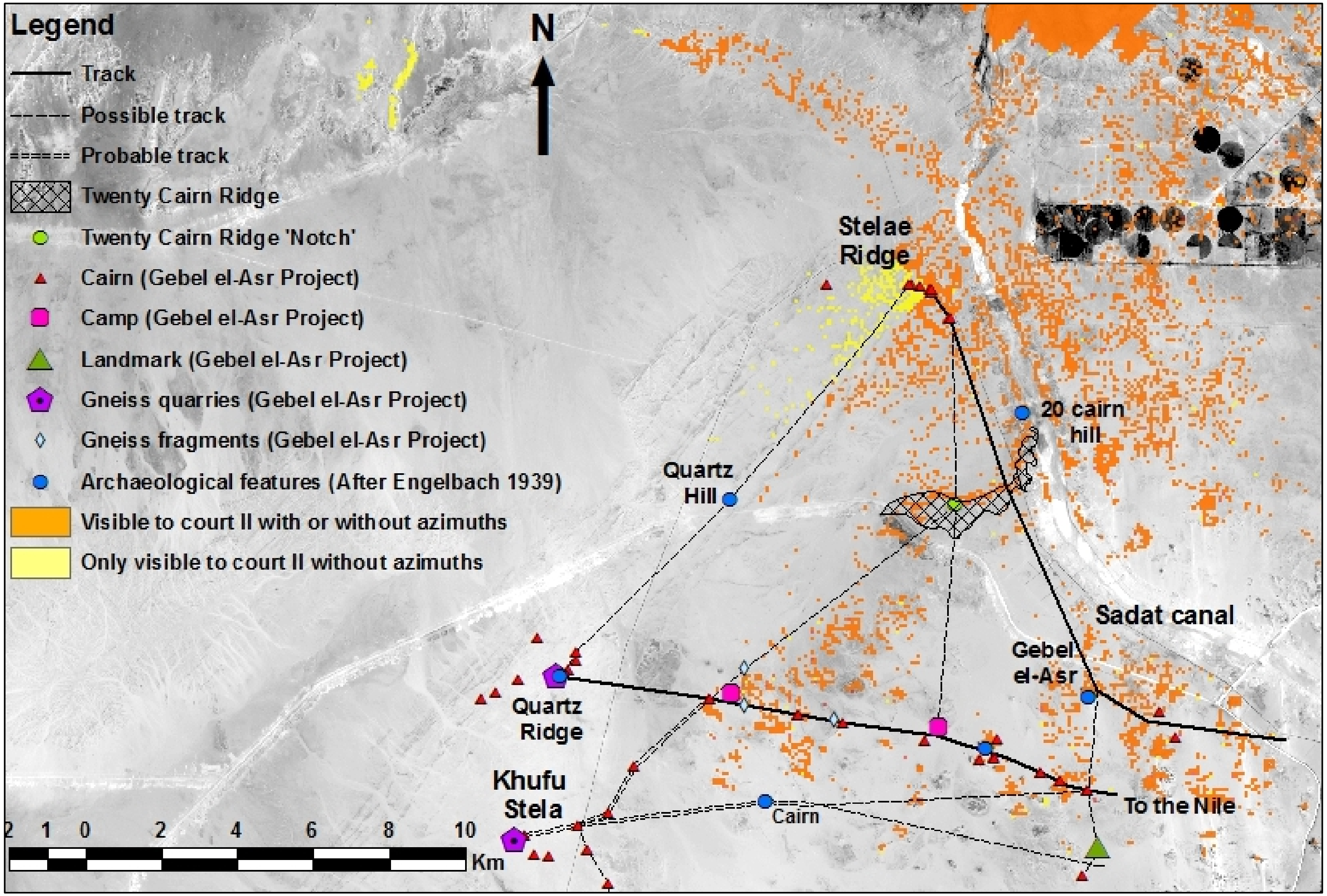


Fig 6.28: The projective viewshed for court II on Stelae Ridge south, showing what was visible from the court with and without azimuths, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

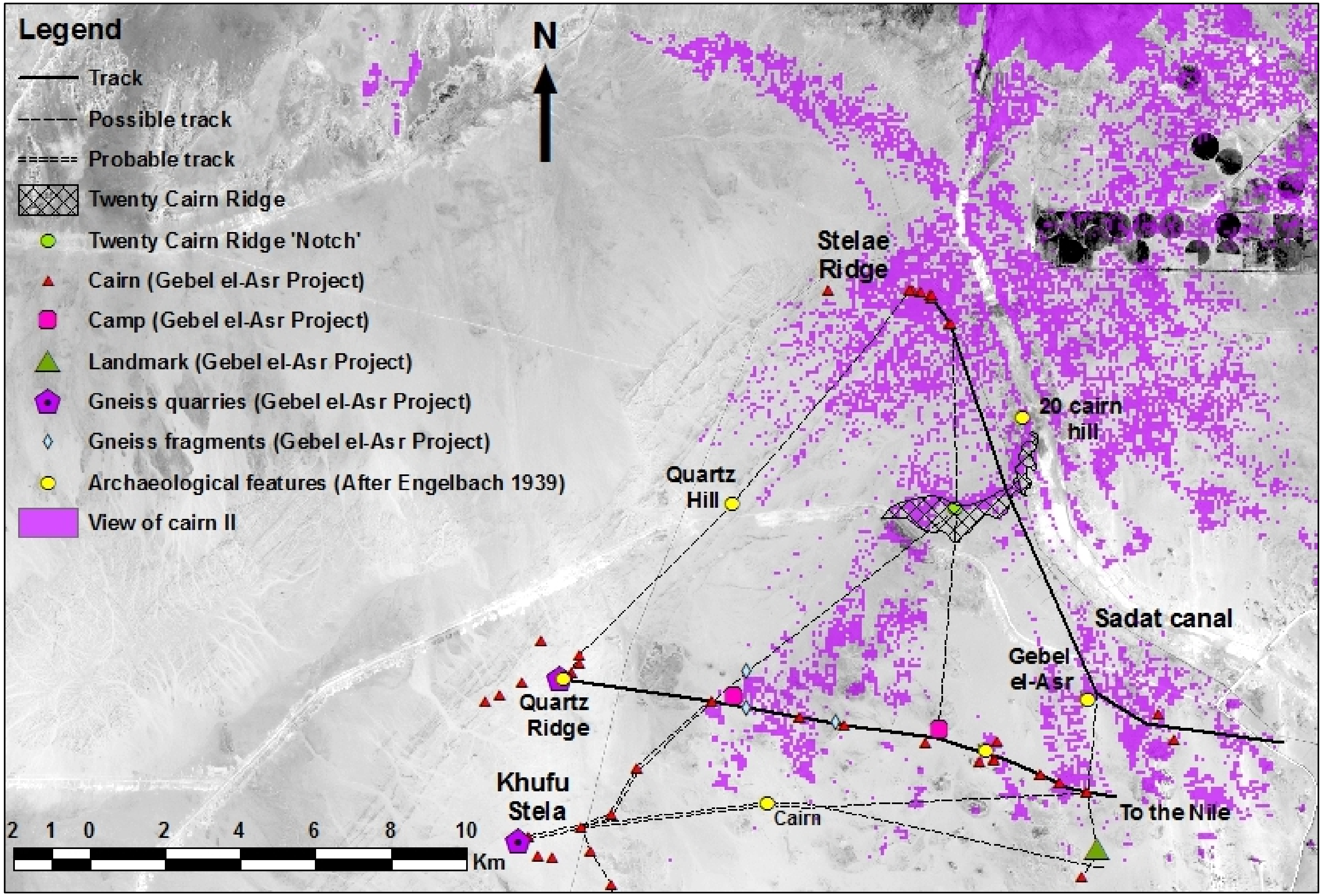


Fig 6.29: The reflective viewshed for cairn II on Stelae Ridge south, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

Cairn-court II's location off the spine of Stelae Ridge south (Fig 6.13) and its small viewsheds (Table 6.1, Fig 6.28 and Fig 6.29) compared to the other structures on Stelae Ridge south, indicate that it is also likely to have been a later addition. This would be consistent with Darnell and Manassa's (2006) suggestion that a year 13 stela of an unnamed Pharaoh from court II, dates to the reign of Amenemhat III.

It is difficult to determine the order of construction for the structures dating to the reign of Amenemhat III. The regnal year was not preserved on the artefacts associated with cairn-court VII. Cairn-courts I and VIII were associated with artefacts referring to regnal year 4, but cairn-court VIII was also associated with artefacts dated to regnal year 6. It may either be dated to the same year as cairn-court I or it could have been constructed in year 6 and the year 4 stelae moved to it, either from cairn-court I or from elsewhere.[307] Although there are two year 4 stelae, they are not particularly large and would not be difficult to move.

The lack of regnal year dates from the artefacts in court VII presents a problem. There are only 4-6 years between the beginning of Amenemhat III's reign and the construction of cairn-court VIII, depending on whether it was constructed in year 4 or year 6. It is possible that cairn-court VII dates to years 1-6 and was constructed before cairn-court VIII. If this was the case it would suggest that visibility had ceased to be a particularly significant issue for cairn-court VII's builders. Otherwise it would presumably have been located further north, in the better position where cairn-court VIII was later constructed.

Alternatively cairn-court VII might be interpreted as the last of the three structures to be built, after both cairn-court I and cairn-court VIII, but it is still unlikely that visibility was the primary factor in the location of the structures during the reign of Amenemhat III. Otherwise it does not make sense for cairn-court VIII to be constructed on Stelae Ridge north by year 6 in a location with poorer visibility, before cairn-court II was constructed in year 13 in a much better position on Stelae Ridge south.[308]

6.3.3. Undated structures

Cairn III and cairn-court V cannot be associated with any specific reign. Cairn-court V is located on the southern ridge, slightly north-west of cairn-court IV and south of cairn-court VI, which is on Stelae Ridge north (Fig 6.13). Cairn-court V is typical of Stelae Ridge, with a

---

[307] If so, it is likely that the motivation for moving the stelae was communal. All the inscribed material found at cairn-court VIII relates to an official named Sabastet (Darnell and Manassa 2013).

[308] Assuming that Darnell and Manassa (2006) are correct and the year 13 stela from cairn-court II dates to the reign of Amenemhat III. If cairn-court II was constructed earlier in the reign of Amenemhat III or in a previous reign, the location of the cairn-courts I, VII and VIII could have been more closely related to visibility.

flat eastern face, a court and inscribed artefacts. Cairn III is south of cairn-court IV on Stelae Ridge south and is atypical, being a round cairn with no court and no artefacts. Although they were not associated with any dating evidence, there are good reasons for interpreting cairn III and cairn-court V as early structures in the chronology of Stelae Ridge.

Since cairn-courts I, VII, VIII, and probably II, were constructed on the periphery of Stelae Ridge because there was no space for them at the centre, it follows that cairns III and V must be earlier because they were located at the heart of Stelae Ridge south, close to the spine of the ridge. There are a number of good arguments against a date during the early part of the reign of Amenemhat III, not least the very unusual shape of cairn III, suggesting it was constructed as a landmark, which would not have been necessary if many earlier cairns were already present on the ridge.[309] If cairns III and V did date to the reign of Amenemhat III it is surprising that they did not produce any dating evidence when multiple other cairns dating to the same reign did. It is also unlikely that these two cairns date to the early years of Amenemhat III's reign, as well as the four that have already been identified. Therefore cairn III and cairn-court V are probably from a period prior to the reign of Amenemhat III and their location on the crest of Stelae Ridge south, close to cairn-court IV, supports this conclusion.

It is likely that cairn III was constructed as a landmark and was probably the earliest structure on Stelae Ridge. The systematic visibility analysis presented in Chapter 5 and other research into the tracks across the Gebel el-Asr quarries and possible alternative locations, revealed that the cairn-courts functioned as landmarks.[310] Those structures on Stelae Ridge south were most suited to this role because of their large viewsheds and inter-visibility with the tracks and locations in the Gebel el-Asr quarries. It is likely that landmarks would have been constructed early in the development of Stelae Ridge, and it is significant that the earliest dated structure, cairn-court IV, was located on Stelae Ridge south and was amongst the top two cairn-courts in terms of viewshed size.

However, cairn-court IV clearly had a ritual and commemorative function, while cairn III was devoid of structural elements or artefacts that could imply such a purpose. It is also similar to

---

[309] For the unusual shape of cairn III and possible explanations for it see Chapter 3, section 3.2.4. The possible association between the good visibility of cairn III and an early date was noted in Chapter 5, section 5.1.2.

[310] Research into the relationship between the visibilities of the cairns and the tracks across the landscape see section 6.1.2 and the conclusions drawn in section 6.1.3. Based on research in section 6.5,1 into alternative ridges which could have housed the Stelae Ridge cairn-courts, section 6.5.3 concludes that Stelae Ridge was probably chosen partly because it provided better visibility of the cairns than any other location.

round marker cairns found at the Gebel el-Asr gneiss quarries and other sites,[311] and was probably constructed with a similar function in mind.

It would not have been necessary to construct cairn III as a landmark if the highly visible cairn IV had already been present, and cairn III is therefore likely to be earlier than cairn-court IV. The proximity of cairn-court IV to cairn III suggests that when it was decided to build a new cairn-court to commemorate early 12th Dynasty activity at the site, cairn-court IV was placed close to the existing marker, cairn III. Elsewhere in Egypt, cairns and enclosures tend to attract other cairns or enclosures, particularly when they have social or ritual elements, and the same is true of inscribed material.[312] In view of this cultural context, it would be surprising if the second structure at Stelae Ridge were located a long distance from the first.

The viewsheds associated with cairn III also support an early date, prior to cairn-court IV, and interpretation of cairn III as a landmark. Cairn III shared the good view and high visibility associated with all the structures on Stelae Ridge south (Fig 6.30 and Fig 6.31). While cairn III was not as visible as cairn-courts IV and V, this probably reflects its position towards the south end of the ridge. It was probably located here because it was primarily intended to function as a landmark for those travelling to and from the Gebel el-Asr gneiss quarries and the route back to the Nile. The builders were probably unaware that in doing this they were locating their landmark in a slightly less visible position because the slight differences between cairn III's viewsheds and those of cairn-courts IV and V were so small that they are unlikely to have been perceptible to subjective observation. In any case cairn III was visible from a wide area of the landscape including the tracks southward to the gneiss quarries and eastward to the Nile, so even if its viewsheds were not quite as large as they could have been they were certainly satisfactory for the function required of it.

---

[311] See Shaw *et al.* (2010, 304) and Engelbach (1939, 388) for more details of the cairns in the Gebel el-Asr gneiss quarries. For similar cairns at other sites see the discussion in Chapter 3, section 3.2.4.

[312] For the grouping of cairns, enclosures and other archaeological features see comparable examples at Hatnub (Shaw 2010, 96–107), site 2 at Gebel el-Zeit (Régen and Soukiassian 2008, 3), the cairns at Mersa Gawasis (Bard *et al.* 2013, 534–546), the structures around Gebel Tingar at Aswan (Storemyr *et al.* 2013, 415–418) and examples in Darnell and Manassa (2013, 56–57). There are numerous examples of how inscriptions attract other inscriptions from all periods. Relevant examples include Site 6 at Wadi el Hudi (Fakhry 1952, 11–12), the inscriptions in Quarry P at Hatnub (Anthes 1928; Shaw 2010), various stelae in the temple at Serabit el-Khadim (Černy *et al.* 1955; Valbelle and Bonnet 1996); multiple sites in the Wadi Hammamat (Couyat and Montet 1912; Lloyd 2013), in Sinai (Petrie 1906) and in the western desert (Darnell *et al.* 2002). Darnell (2009), Garnett (2013), Riemer and Förster (2013, 39–42) interpret the accrual of archaeological features, petroglyphs and texts as part of an active process of memorialising and place-making in desert locations.

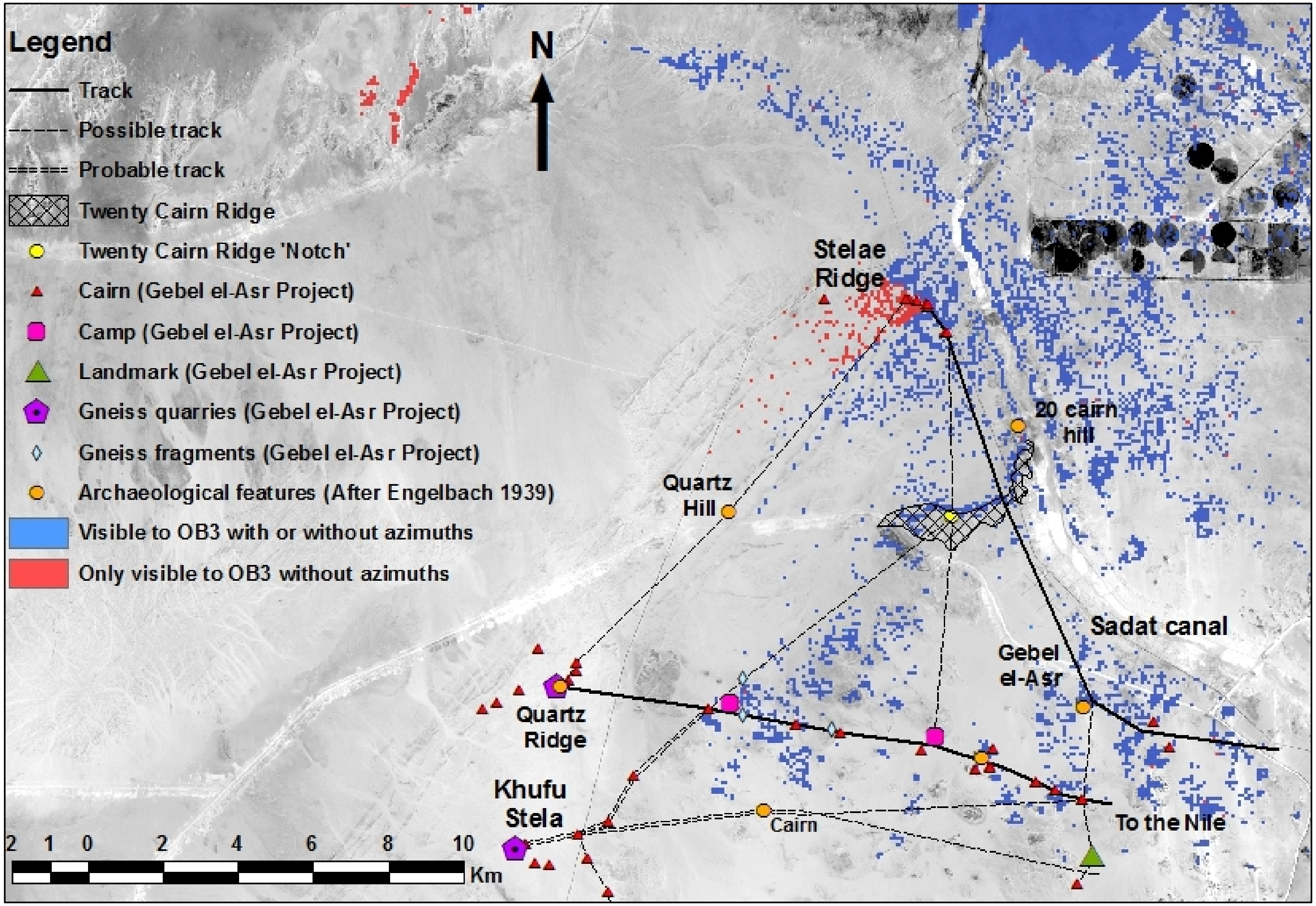


Fig 6.30: Projective viewsheds for OB3, showing what was visible to an observer to the east of cairn III, with and without azimuths, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

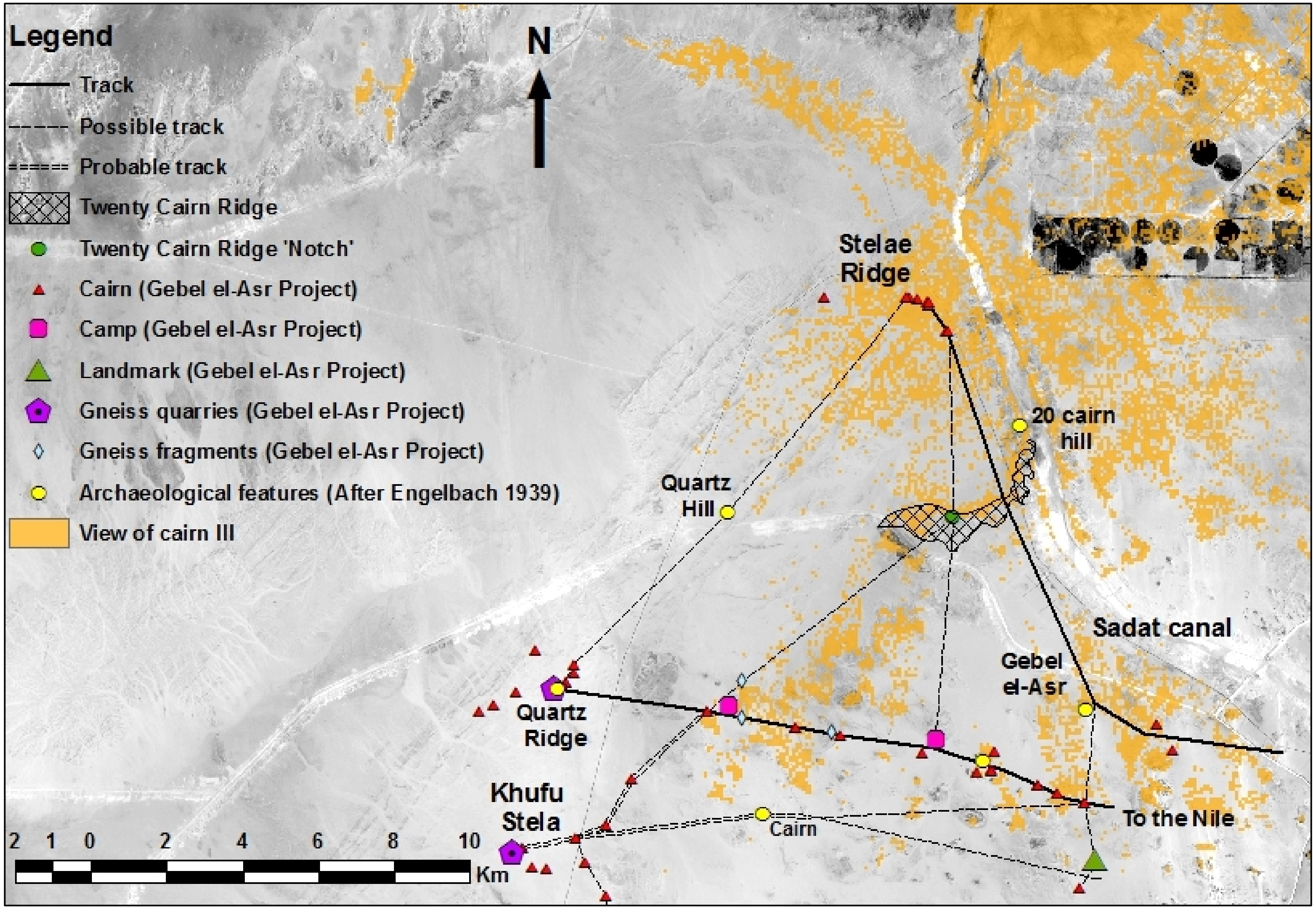


Fig 6.31: Reflective viewshed for cairn III, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

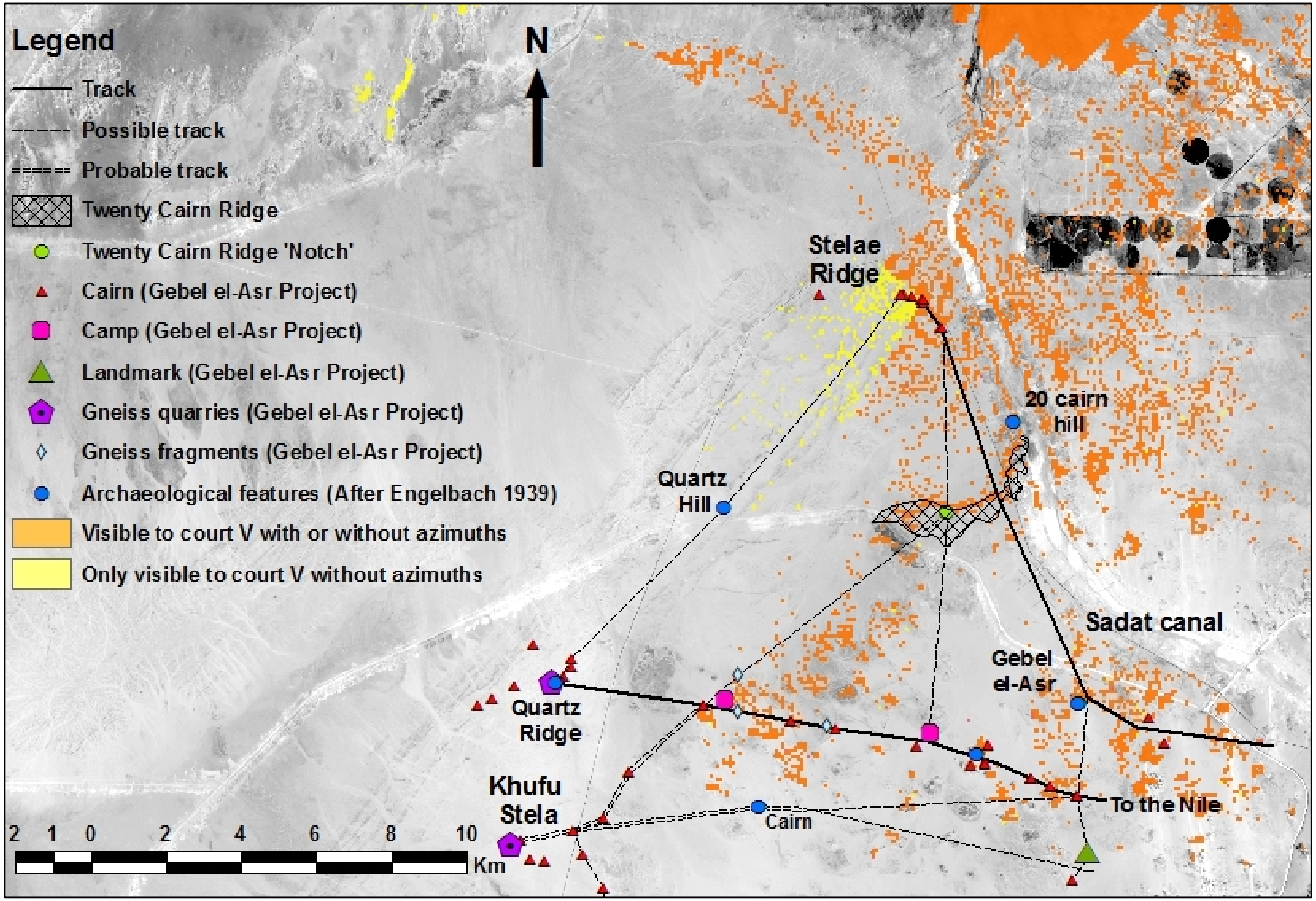


Fig 6.32: Projective viewsheds for court V, showing what was visible to the court, with and without azimuths, depicted overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

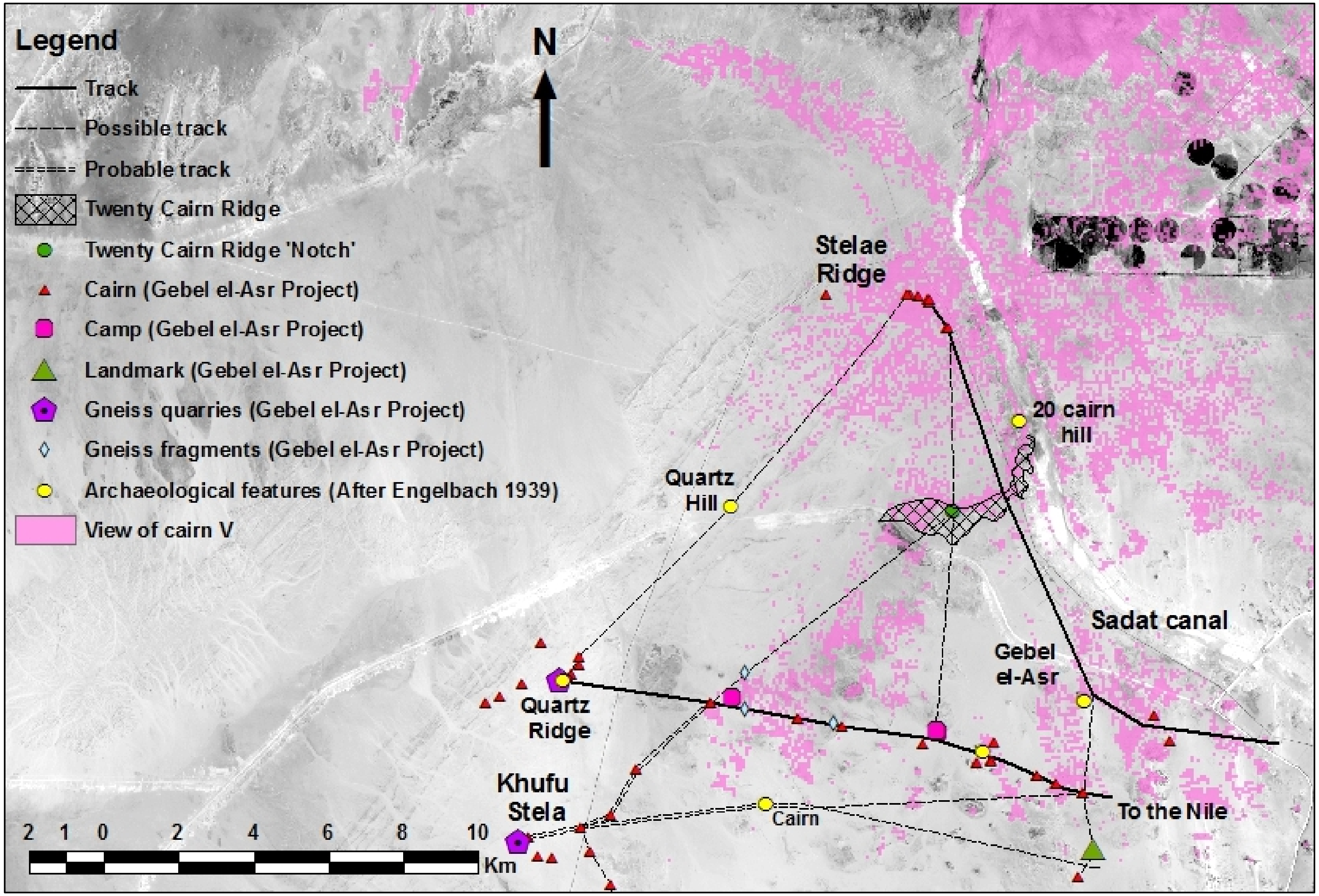


Fig 6.33: Reflective viewshed for cairn V, showing where the cairn was visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

It may be significant that cairn III remained the southernmost cairn on Stelae Ridge south until the construction of either cairn I in the reign of Amenemhat III or cairn II, if that was constructed before his reign. This suggests that some effort was made to keep cairn III visible from the south even after other cairns were constructed and implies that subsequent generations of miners at Stelae Ridge were aware, and perhaps grateful, that this cairn functioned as a landmark.

Cairn-court V was probably the third structure built at Stelae Ridge, after cairn III and cairn-court IV. Court V has the second largest projective viewshed with or without azimuths (Fig 6.32) and cairn V has the largest reflective viewshed of all the cairns on Stelae Ridge (Fig 6.33). This places it amongst the top three structures for viewshed size in Table 6.1. The other two, cairn III and cairn-court IV, are located on either side of it and are both early. In view of its location, north of cairn-court IV and south of cairn-court VI, cairn-court V is likely to pre-date court VI, but be older than court IV. This would place it between year 20 of Senusret I and the reign of Senusret II, perhaps in the reign of Amenemhat II who is attested at Stelae Ridge by a stela found near cairn 013, *c.*100m to the west.[313]

6.3.4. Conclusion

The archaeological, epigraphic and visual evidence suggests that visibility was initially important in the construction of the earlier cairns, but later reduced in importance as earlier structures ensured the site remained visible wherever later ones were placed. Cairn III is interpreted as the earliest structure, constructed to mark the Stelae Ridge area perhaps in the sole reign of Amenemhat I, before his co-regency with his son Senusret, or at some point before then in the early Middle Kingdom, or even the Old Kingdom. Cairn-court IV was the next structure, probably created during the co-regency of Amenemhat I and Senusret I to commemorate the re-opening of the site. Based upon its position between cairn-court IV and VI, cairn-court V was built after cairn-court IV sometime between year 20 of Senusret I and year 8 of Senusret II. All of these structures were highly visible and possessed good views of the landscape, although it is impossible to be certain whether this was a deliberate decision in the case of cairn-courts IV and V or an accidental effect of a desire to locate them close to cairn III. It may be a combination of both factors, with the builders of cairn-courts IV and V locating them in highly visible positions after being attracted to Stelae Ridge south by cairn III.

[313] For the discovery of the stela of Amenemhat II see Shaw (2003, 453). For cairn 013 see Chapter 3, section 3.7.2.

Once the first three structures, III, IV and V were constructed, space on Stelae Ridge south was reduced and its visibility was assured, so the builders moved onto the less visible northern ridge with cairn-court VI. They may previously have moved off Stelae Ridge to the west to construct cairn 013, where a stela of Amenemhat II was found. By year 4 of Amenemhat III, new structures were constructed at the north and south ends of the Stelae Ridge ridges as space permitted. Cairn-court I was built at the south end of Stelae Ridge at roughly the same time as cairn-court VIII was located at the north end, although the latter could possibly have been built after cairn-court I in year 6. Cairn-court VII may have been built either before or after VIII. Cairn-court II was the last construction undertaken in year 13 in the remaining space on the southern ridge.

This model of the chronological development of Stelae Ridge offers the best explanation of all the available sources of evidence and does not privilege visibility to the exclusion of other factors.[314] However, the evidence would also permit a reconstruction where cairn-court II was built earlier in the 12th Dynasty before cairn-court VI, and several permutations where cairn-court I was an earlier cairn re-used or reorganised by the expeditions of Amenemhat III.

6.4. Visibility between Stelae Ridge and the mining area

A significant feature of the Stelae Ridge structures is that the cairns are all located to the west of the courts. The consistency in the location suggests that this is not accidental and the courts were deliberately placed to the east of the cairns for some reason. If Engelbach's claim that the cairns covered inhumations was correct,[315] the western position of the cairns might be associated with the relationship between the west and the afterlife in Egyptian thought.[316] The position of the cairns could also be considered in relation to prescribed orientations for rituals, but this possibility cannot be explored through visibility analysis and must await evidence from another source.[317] There could also be a practical explanation. The cairns may have been constructed on the western side of the courts to provide some

---

[314] Given how much less visible Stelae Ridge north is than Stelae Ridge south, if visibility had been a crucial issue for all the cairns, it would have been more sensible to avoid building on Stelae Ridge north altogether and construct cairn-courts VI–VIII elsewhere.
[315] For this suggestion and arguments against it see Chapter 1, section 1.2.2.
[316] While this is generally true, there are some notable exceptions detailed in Jeffreys (2010, 109).
[317] Research into funerary rites suggests that orientation was significant in rituals (Raven 2005). Scenes in early New Kingdom tombs reveal that images of deities, royalty and deceased ancestors tend to be presented facing out from the west, while living offering bearers and visitors to the tomb face towards them (Robins 2010). Little research has been undertaken into the wider role of orientation in non-funerary rites, but given the westerly orientation of the cairns, it is possible that the rituals undertaken at the site could involve a similar or related paradigm.

protection from the hot westerly winds and sandstorms blowing in from the Sahara, just as at Amarna an awareness of the prevailing wind has been interpreted as influencing the construction and orientation of bedrooms (Endruweit 1994, chapter 4).

There is one further possibility, which can be investigated through visibility analysis. The cairns may have been constructed to the west of the courts to separate individuals and activities in the courts from the view of miners working in the main mining area to the west (Fig 6.34).[318] This separation could be associated with the ritual nature of the structures and the religious or commemorative activities which took place in the courts. Separation is a facet of ritual generally[319] and is specifically associated with Egyptian ritual and religion.

In Egyptian temples a ritual context was created by separating the cult, ritual or magic space from the secular or mundane world outside. Egyptian temples were separate ritual spaces defined by purification rituals, with ever-decreasing levels of access from the outside to the central shrine. [320]

Shrines and chapels were more accessible to the wider populace, but were usually physically separated from secular structures. Chapels constructed at the periphery of temple complexes were constructed partly within or attached to the enclosure wall of the temple and were therefore intimately connected to the ritual space.[321] Away from temples, this separation continued. All the different types of garden shrines at Amarna were separated from the rest of the garden either by their own compound wall, their elaborate approaches, their layout or the presence of architectural features like walls around the edges and stairs

---

[318] This is not to suggest an absolute separation between the cairn-courts and any mining or working area, merely an effort to separate the main area of mining, where the mines were most concentrated, from the cairn-courts. There are some isolated mines to the north and south and a possible working area identified to the east of Stelae Ridge, which may have been inter-visible with the courts. Inter-visibility with small and isolated mining or working areas may have been considered acceptable. Alternatively, as these smaller features have not been tested by excavation, it is uncertain if they really were working or mining areas and if so, whether they date to the same period as the Stelae Ridge cairns.
[319] Separation of the ritual context from others is a key element of both Renfrew's (1985; 16–21 and 25; 1994b, 51–53) and Verhoeven's (2011, 126–7) methods for the identification of ritual contexts, suggesting that this idea bridges the divide between highly processual approaches and more flexible post-processual ones, even though it is not an essential component of all ritual (Bell 1997a, 138).
[320] For the Egyptian temple as a separate ritual space created by foundation rituals see summaries in Hornung (1992, 118); Shafer (1997) and Wilkinson (2000, 38–39). For the consecration of temples and foundation rituals see summary and references in Černy (1952, 114–115); David (1973, 70–72); Letellier (1977); Shafer (1997); Zibelius-Chen (1986). For specific examples see Blackman and Fairman (1946) and Engelbach (1934). For foundation deposits see Weinstein (1973). For ritual purity see Blackman (1918, 3–21), Shafer (1997, 10). For restricted access to temples see Assmann (2001, 31–32); Baines (1991, 126; 148); Bell (1997b, 135–136); Hornung (1992, 126); Shafer (1997, 10).
[321] For chapels on the periphery of temple complexes see the summary and references in Teeter (2011, 77– 84).

along the approach.[322] At Deir el-Medina and the Amarna workman's village, chapels were clustered outside the settlement and sacred space within them was separated from secular space by the chapel's external and internal walls.[323] Similar chapels were found at Zawiyet Umm el-Rakham.[324]

Other shrines were secluded by virtue of their location. The early Dynastic and Old Kingdom phases of the temple of Satet at Elephantine made use of a niche between two boulders, which was enhanced with additional mudbrick walls.[325] The village shrine of Meretseger served the village of Deir el-Medina at Luxor and was located in and around a limestone outcrop. It's location at some distance from the village separated it from the business of living and its position between limestone outcrops and overhangs provided some seclusion.[326] The Hathor cave at Serabit el-Khadim is another similar example.[327]

Evidence for religious activity in the home is limited, but where present it is often associated with a specific structure or setting intended to create a ritual space. Although set in a domestic context, household altars and lustration slabs were set apart from their surroundings by their construction, materials, appearance or decoration.[328] Even temporary magical rites may have required rituals for separating magical space from secular space.[329]

In view of this evidence it is not surprising that the visibility analysis of the courts presented in Chapter 5, section 5.1 and 5.2 revealed that the cairns restricted views to the west and limited visibility of the courts from the same area.[330] A more detailed review of the visibility

---

[322] For garden shrines see Ikram (1989) and Stevens (2006, 253–254).
[323] For private chapels at the Amarna workman's village, Deir el-Medina and parallels see Bomann (1991). The chapels at Amarna are also considered by Stevens (2006, 251-253), together with similar structures from the main city and garden shrines at private houses.
[324] For the chapels within the temple enclosure see Snape and Wilson (2007, 33–68). The excavators interpreted them as private chapels, similar to those at Deir el-Medina and Amarna (Snape and Wilson 2007, 91).
[325] The phases and structure of the early shrine of Satet are summarised in Kemp (2006, 116–121) following the original publication by Dreyer (1986).
[326] Teeter (2011, 84-86) summarises the shrine and its location.
[327] The recent re-investigation of the temple and its rock-cut shrine are described in Valbelle and Bonnet (1996).
[328] Weiss (2009) identifies the distinctively shaped and decorated *lit clos* from the village of Deir el-Medina as altars for household rites. Other altars and lustration slabs from houses at Amarna are discussed in Stevens (2006, 219–235).
[329] See for example the reconstruction of the magical aspects of childbirth in Middle Kingdom Egypt in Wegner (2010, 127–132), particularly the creation of a 'protective perimeter'.
[330] Although the azimuths used to model the effect of the cairns upon visibility exaggerated the extent to which the cairns would limit visibility, the cairns would certainly have had some effect, particularly upon visibility of the courts from low areas of the landscape. The evidence presented in Chapter 5, section 5.2 suggested that reality probably lay between the visibility analysis with azimuths and that without azimuths.

analysis of the courts was undertaken to determine how visible the main mining area was to individuals in the courts and how visible the courts were to people in that area.

6.4.1. Inter-visibility between the courts and the mining area

Fig 6.35 shows the projective cumulative viewshed analysis of the area immediately west of the Stelae Ridge cairn-courts and reveals how visible the main mining area would have been to participants undertaking activities within the courts. Fig 6.36 is a detail of the reflective cumulative viewshed showing how visible the courts were to individuals present at the mining area to the west.

A comparison of Fig 6.36 with Fig 6.35 indicates there is quite good reciprocity between the projective and reflective cumulative viewsheds although there are some slight differences. The main mining area, including the large mine (Mine 1), is mostly excluded from both the projective and reflective cumulative viewsheds of the courts. This area would have been obscured from of individuals in the courts and those in the mining area would not have been able to see into the courts. But part of the large mine (Mine 1) is inter-visible with two of the eight courts, which the observer points analysis shows were court I and OB3 east of cairn III. Since OB3 was not located in a court and cairn III probably did not have the same ritual purpose as the other cairn-courts, in reality only one of the seven ritual courts would have been inter-visible with the large mine. Given the low resolution of the SRTM, the subjectivity in the creation of the azimuths and uncertainty about the precise original height of the cairns, it is entirely possible that the mining area was even less visible than the cumulative viewshed analysis suggests.

The mining area may also have had less visibility of the courts because of the topographic effects of mining. Excavation of mines by both Engelbach (1939, 372) and the Gebel el-Asr Project revealed that they had been cut into the desert surface, creating open pits or trenches of up to 2m deep where chalcedony was extracted (Bloxam 2006, 289; Shaw *et al.* 2010, 303). Individuals working in them would have been up to 2m lower than the modern ground level, which is the level represented by the SRTM cells and employed in the visibility analysis. As a result individuals within the mines would have had less of a view of the courts and been less visible to them than is indicated by the visibility analysis.

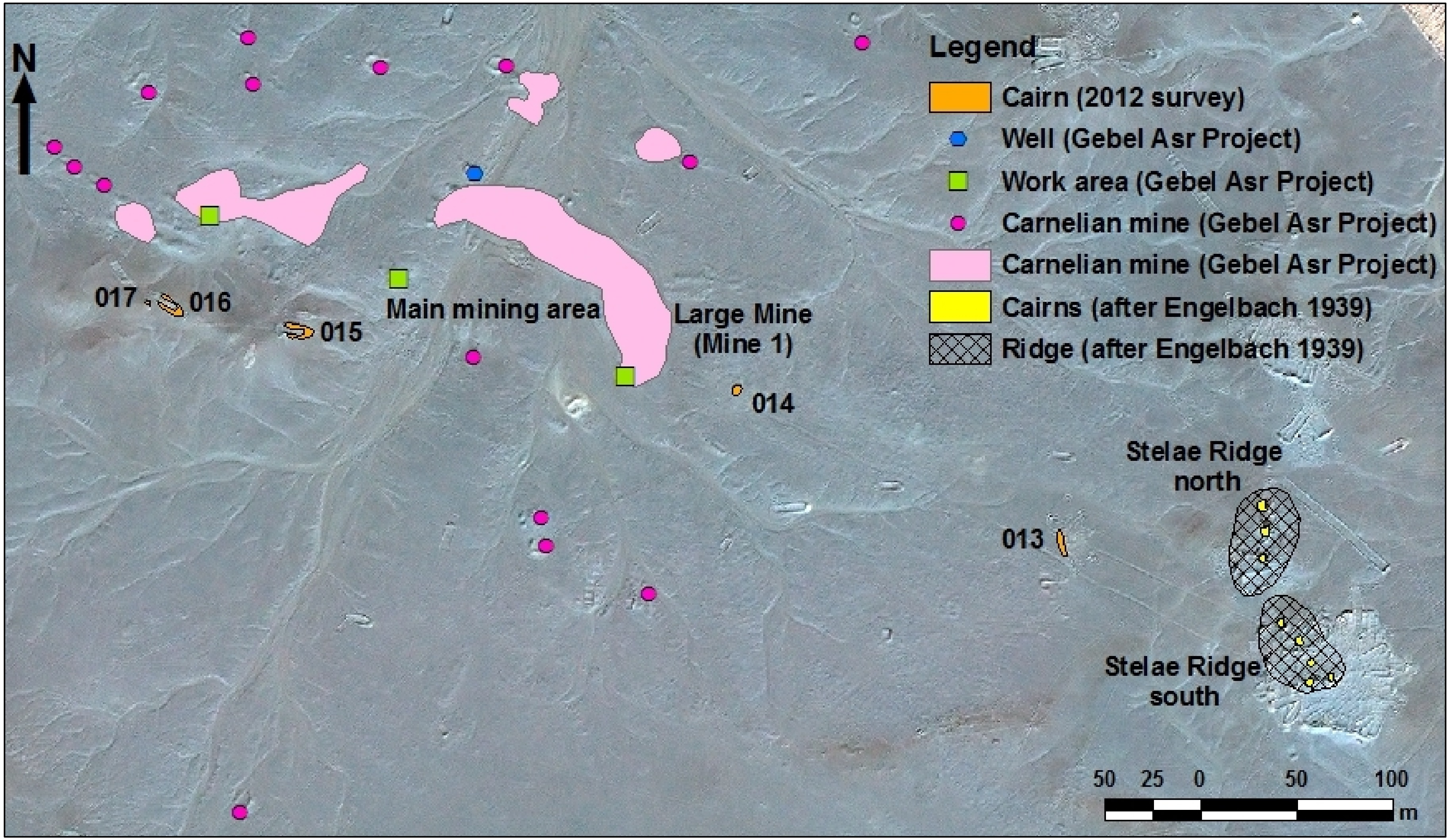


Fig 6.34: Detail of Stelae Ridge and the area to the west, including the main mining area and the three cairns 014, 015 and 016. Archaeological features are shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

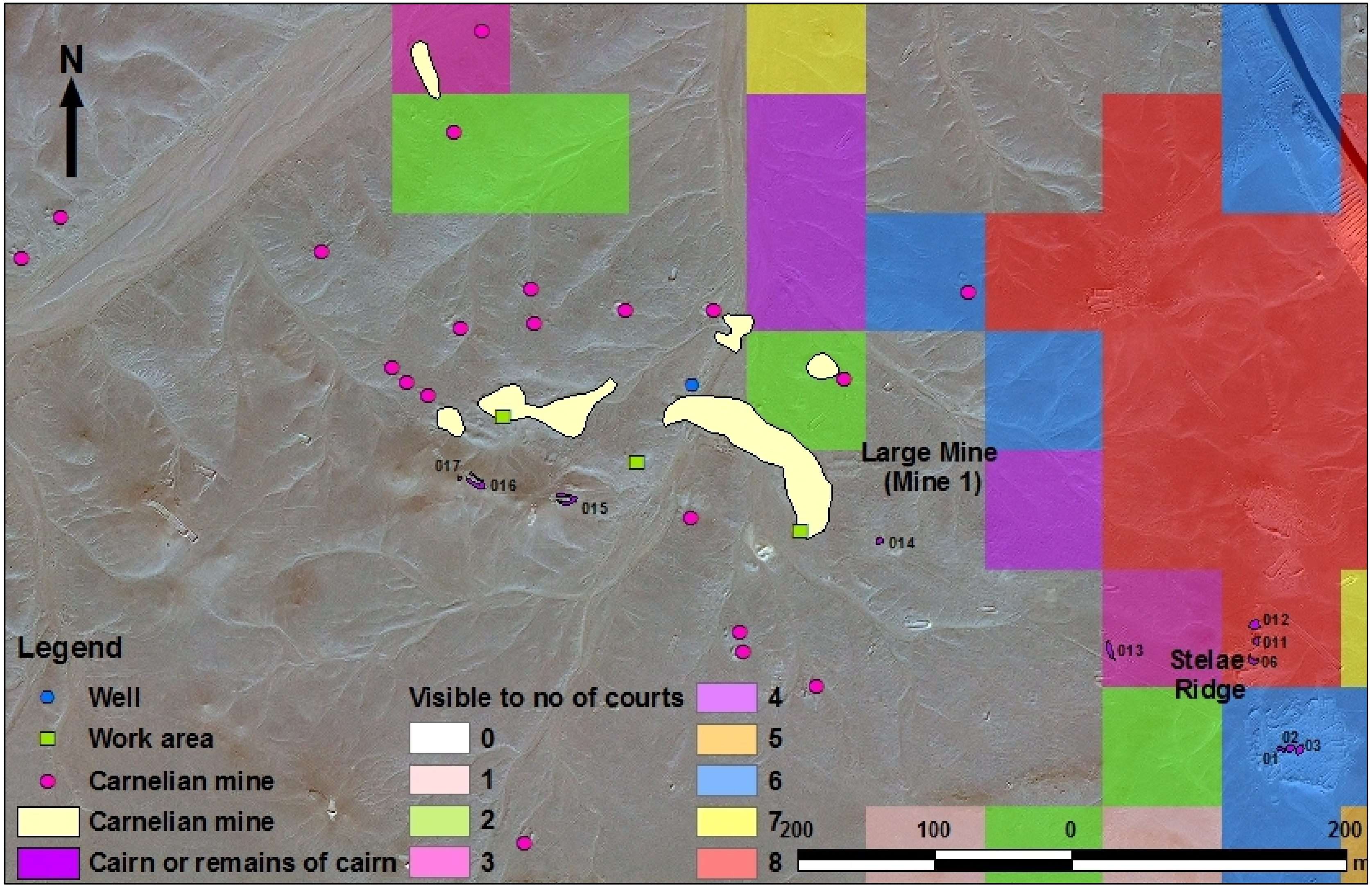


Fig 6.35: Detail of the projective cumulative viewshed analysis, with azimuths, showing what was visible to the Stelae Ridge courts, overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

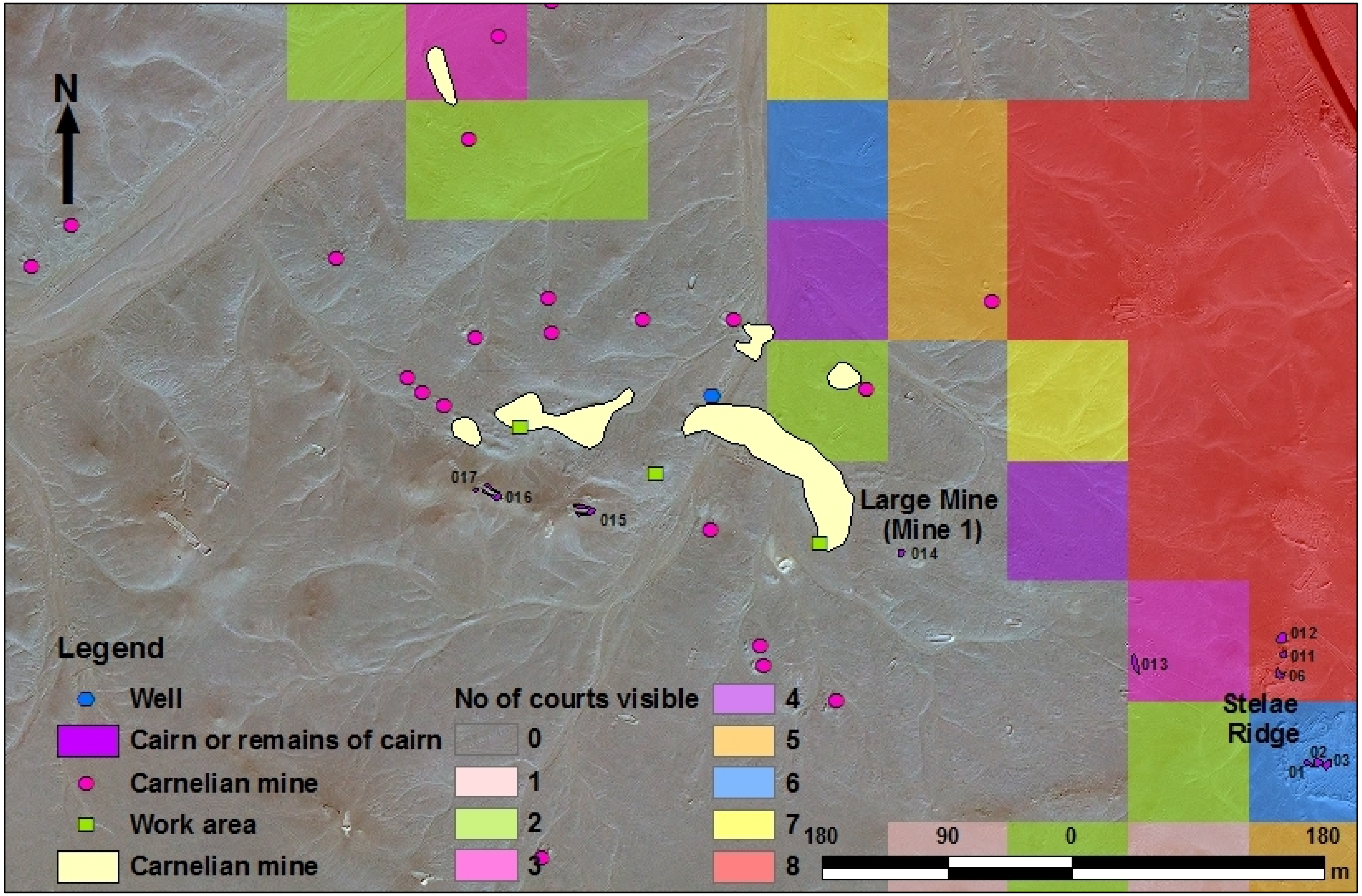


Fig 6.36: Detail of the reflective cumulative viewshed analysis with azimuths, showing how visible the courts were to observers in the main mining area, overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

The combination of limited visibility of the mining area from the courts and restricted views of the courts from the mining area rendered them relatively secluded areas in an otherwise very flat and open landscape, which generally provides little opportunity for privacy or seclusion. Considering the flatness and openness of the landscape, this is suggestive of a deliberate attempt to create separation between the ritual activities in the courts and the hard work of mining, consistent with the separation and seclusion exhibited by other Egyptian ritual structures. It is not possible to prove with certainty that this was the primary or the only motivation for the location of the cairns to the west of the courts, but it seems likely that even if the cairns were located in this position for other reasons, their imposition between the courts and the mining area would also have been considered advantageous.

6.4.2. Inter-visibility between the courts and the mining area prior to construction of the cairns

If the mining area was obscured from the Stelae Ridge courts by the cairns, the question arises as to whether these locations were inter-visible prior to construction of the cairns and if that influenced the location of the Stelae Ridge structures. Since the effect of the cairns on visibility was modelled through the azimuths, the cumulative viewshed analysis without azimuths provides an indication of the visibility prior to construction of the cairns.

Fig 6.37 and Fig 6.38 show the projective and reflective cumulative viewshed analysis created without azimuths, focussed on the area immediately west of the cairns. Naturally, removing the azimuths increased the area of the viewsheds, just as the landscape would have been more visible before the cairns were built. However even without the cairns, visibility between the courts and the mining area is limited to a surprising extent around and west of the large mine, particularly considering the flatness of the landscape. This raises the possibility that Stelae Ridge may have been selected for ritual structures because, even before the cairns were constructed, it had relatively limited views of main mining area and was not clearly visible from it. This feature of Stelae Ridge was then enhanced by the construction of the cairns to create even more secluded areas in the courts, probably for ritual activities.

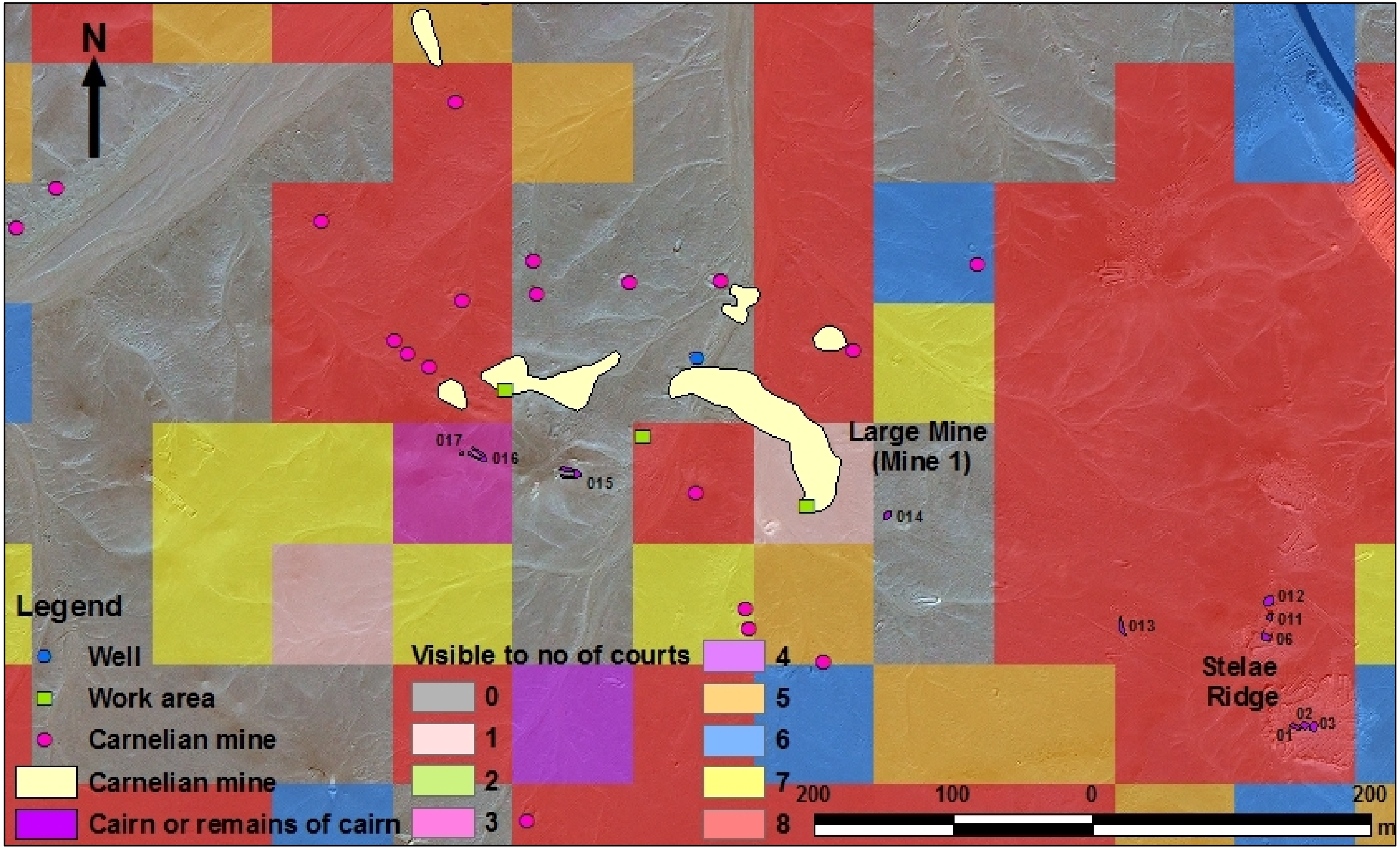


Fig 6.37: Projective cumulative viewshed without azimuths showing what was visible from the courts, prior to construction of the cairns, overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

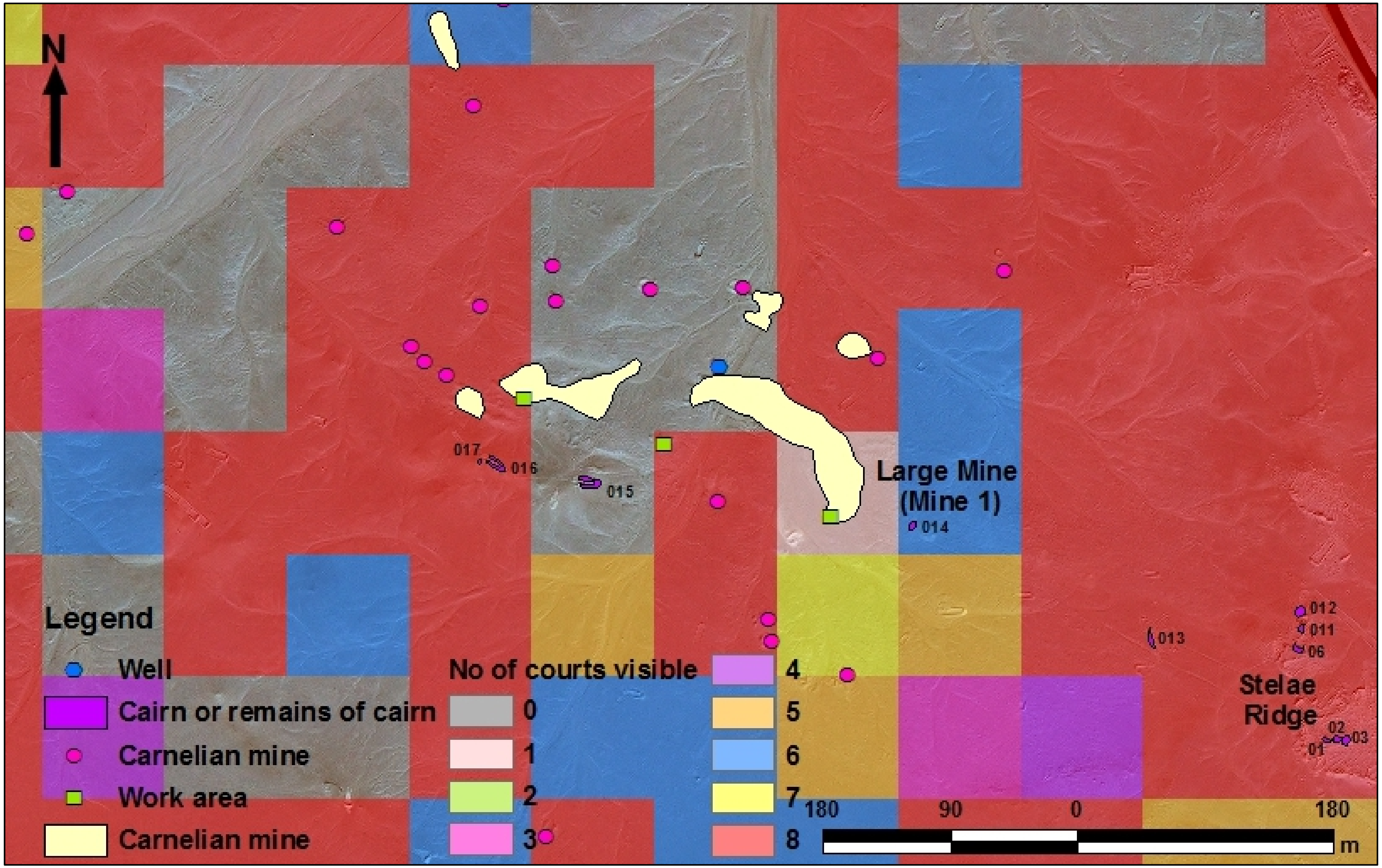


Fig 6.38: Detail of the reflective cumulative viewshed without azimuths showing how visible the courts were, prior to construction of the cairns, overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

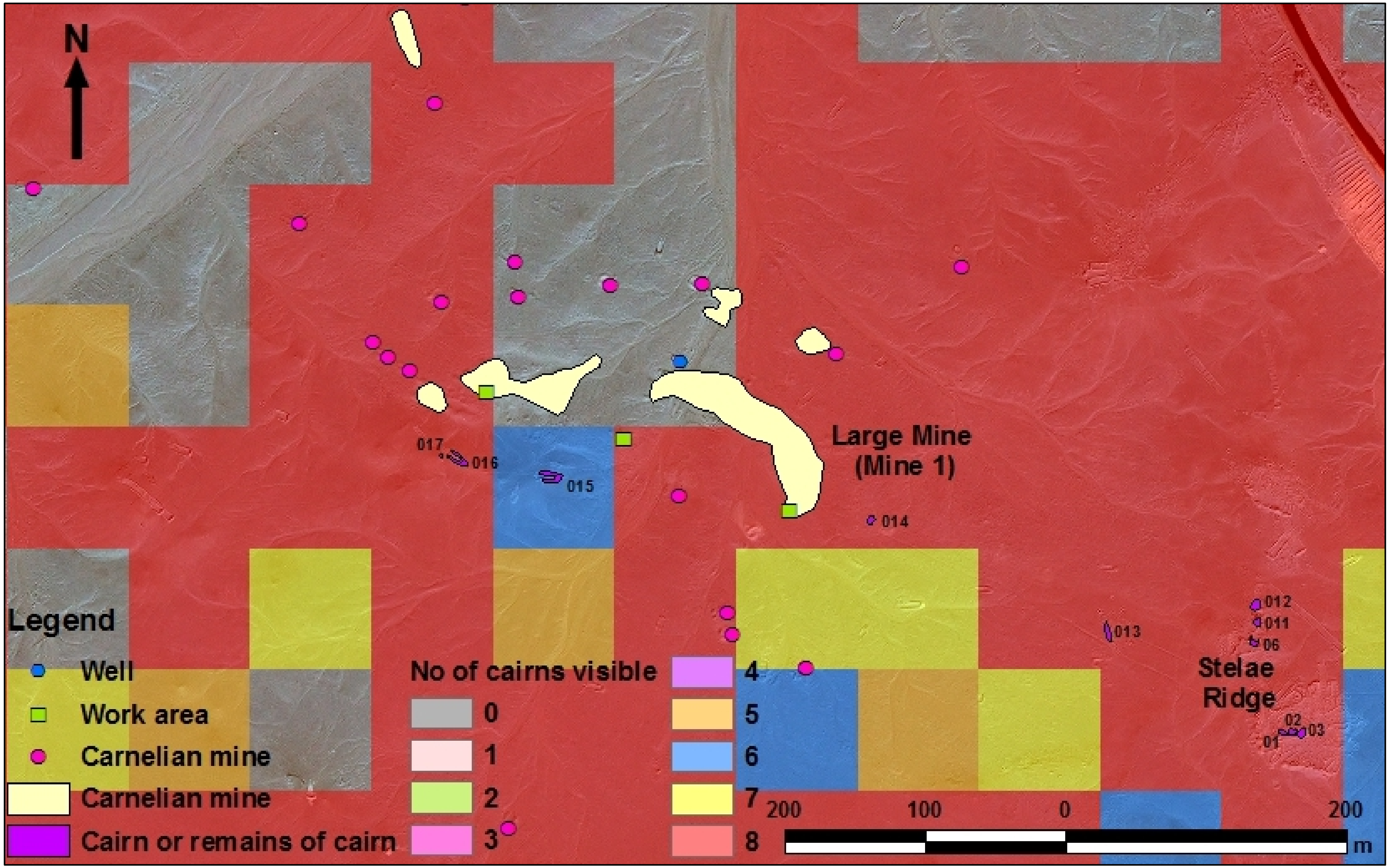


Fig 6.39: Detail of the reflective cumulative viewshed of the cairns, showing how visible they were to observers in the mining area, overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

6.4.3. Visibility of the cairns from the mining area

The fact that the Stelae Ridge structures were positioned on a ridge implies some desire for prominence and this prominence would have been enhanced by the construction of the cairns. The author's experience of visibility at the site,[331] determined that cairns enhanced the visibility of the hills or ridges they were located upon and the systematic visibility analysis revealed how visible the cairns were.

Fig 6.39 is a detail of the reflective cumulative viewshed of the cairns, showing how visible they were to observers in the mining area. As expected, the Stelae Ridge cairns were visible to a high proportion of the primary mining area, although some parts did not have a view of them. The cairns were more visible to the mining area than the courts, primarily because of their height. The visibility analysis did not consider the effect of their mass or their being outlined against the sky, but both of these features would enhance visibility and recognition of the cairns.[332]

6.4.4. Conclusion

Even prior to the construction of any structures upon it, the cumulative viewshed analysis without azimuths reveals that the ridge chosen for the eight Stelae Ridge cairns had limited inter-visibility with the main mining area to the west. The construction of the cairns, consistently on the west side of the courts, further reduced the view of the courts from those in the mining area and visibility of the mining area from anyone in the courts. Visibility would have been reduced further by the depth of the mines, which would have locally reduced ground level by up to 2m. It is impossible to be certain if the cairns were constructed to the west of the courts out of a desire to separate the ritual areas in the courts from the mining area, but the evidence is suggestive and consistent with Egyptian practice. This interpretation does not preclude other ritual or practical aspects to the position and orientation of the cairns compared to the courts, but the alternative interpretations cannot be investigated using visibility analysis.

The choice of the ridge as a location for the courts implies some tension between the need for seclusion, and the need for prominence in the location of the Stelae Ridge structures. The reflective cumulative viewsheds show that the courts were relatively visible from the mining area, purely by virtue of their location on a local high point. Had seclusion been the sole aim of the builders, one would have expected them to construct the courts in a

---

[331] For the practical experience of visibility at the site see Chapter 3, section 3.7.3.
[332] On the Abu Ballas trail it was noted that *alamat* could be very small, but still highly visible when outlined against the sky (Riemer 2013, 91).

depression or behind a ridge, rather than upon one. The presence of the structures on a ridge, implies that there was some need for prominence, and this is also implicit in previous conclusions that the cairns functioned as landmarks. At the same time, the reduced visibility of the mining area from the unmodified ridge, combined with the location of the cairns between the mining area and the courts suggests a preference for a visual separation between the courts and the working area. This tension is also consistent with other Egyptian structures. Elements which separate a ritual space may also serve to enhance its external prominence, from temple enclosure walls to low balustrades around household altars.

6.5. Possible alternatives to Stelae Ridge

The systematic visibility analysis in Chapter 5 and sections 6.1 and 6.2 of this chapter have shown that the Stelae Ridge structures formed effective landmarks, particularly for people approaching from the Gebel el-Asr quarries to the south. Section 6.4 has shown how the topography of Stelae Ridge, enhanced with the cairns, provided a compromise between visible cairns and secluded courts, screened from the view of people in the mining area. This section considers whether Stelae Ridge provided a better location in respect of these properties than other alternative ridges around the mining area, and therefore whether it is likely to have been these properties which attracted the cairn builders to Stelae Ridge rather than any other location.

Fig 6.40 shows the most likely alternative locations for cairns around the main mining area. Some of the other ridges were actually used for cairn construction. The ridge immediately south of the main mining area, hosted two cairns (015 and 016), which were surveyed by the Gebel el-Asr Project and the 2012 survey. Engelbach comments that ‘further cairns, similar to those on [Stelae] ridge, some having stelae or votive hawks, were found in the area to the west of the ridge, the furthest being about half a kilometre distant (Engelbach 1933, 69)’. Since the two large cairns on the ridge immediately south of the main mining area have been pushed over, it is impossible to tell if they were originally associated with courts and artefacts or not, but it is possible that they were amongst the ‘further cairns’ described by Engelbach. These demolished cairns 015 and 016 were included in the analysis together with cairn 013, which was associated with a stela of Amenemhat II and lies *c.* 100m west of Stelae Ridge, and the small surviving cairn 014, which had no evidence of a court.

Other locations were chosen, based upon their proximity to the main mining area and their height above sea level as indicated by the SRTM. Only areas of 192m or above were considered. Since cairn-courts were constructed upon Stelae Ridge north, which is 192m above sea level, it can be assumed that any alternative would need to be at least as high.

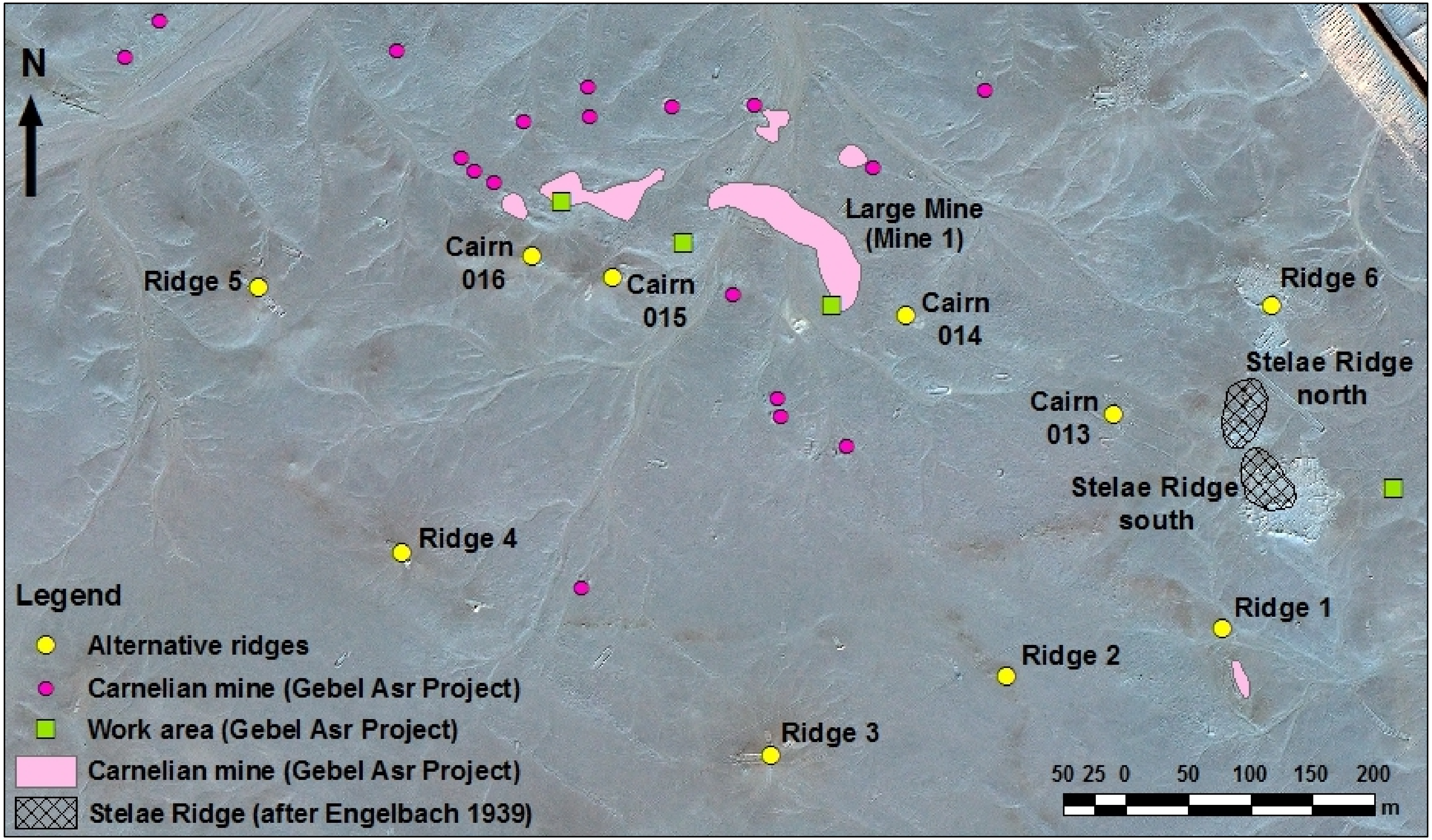


Fig 6.40: The area around Stelae Ridge and the main mining area, showing possible alternative locations for the structures ultimately built on Stelae Ridge. Features are shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

Since the precise position of any cairn or court at these alternative locations is not known, the visibility analysis of them was run without azimuths. The projective observer points analysis of these points used an observer height of 1.6m and a target height of 0m, representing a human observer viewing the landscape from the ridge. The reflective observer points analysis used an observer height of 1.6m and a target height of 1.28m, representing human observers across the landscape looking at a cairn of 1.28m. The 1.28m height was chosen because this was the mean height of the two surviving cairns on Stelae Ridge and had been used as the height of all the cairns on the ridge in the reflective visibility analysis of the cairns. Ground level at each location was taken from the SRTM.

The projective and reflective viewsheds for each point were then extracted from the observer points analysis for comparison with Stelae Ridge. It would be unfair to compare each alternative location with all the eight cairns on Stelae Ridge, so cairn III was chosen to represent Stelae Ridge on the basis that it was a landmark and was probably the earliest cairn on the ridge. It should be remembered that cairn III did not have the largest reflective viewshed and OB3, to the east of it, did not have the largest projective viewshed. Furthermore, the presence of multiple cairns on Stelae Ridge will have enhanced the visibility of the ridge from a larger area as the number of cairns on the ridge increased. A comparison with cairn III is therefore likely to underestimate slightly the size of the area visible from Stelae Ridge and the area from which it was visible.

6.5.1. Visibility of alternative ridges and cairns in the landscape

The viewsheds for each alternative location are shown in Fig 6.41–Fig 6.50. They should be compared with the projective and reflective viewsheds for cairn III and OB3 in Fig 6.30 and Fig 6.31. Table 6.2 shows the sizes of the total visible areas of the projective and reflective viewsheds for cairn III and OB3, on Stelae Ridge, and each alternative location. To ensure it is comparable with the alternative locations, the projective viewshed for Stelae Ridge is that calculated for OB3 without azimuths.

Stelae Ridge, in the form of OB3 and cairn III, has the largest projective and reflective viewsheds, larger than any of the alternative ridges and cairns. None of the alternative locations would have provided such a good view, or been as visible as Stelae Ridge, represented by cairn III and OB3. Given that other structures on Stelae Ridge had larger viewsheds than cairn III and the visibility of Stelae Ridge would have increased with additional cairns, overall it is likely to have had even better visual properties than is suggested by the viewsheds for cairn III.

Table 6.2: Areas of the projective and reflective viewsheds for the alternative locations around the main mining area at Stelae Ridge.

Location	Area visible (Projective)		Area where cairn is visible (Reflective)	
	Number	Area (km^2)	Number	Area (km^2)
Cairn III/ OB3 Stelae Ridge	16229	121.32	25229	188.60
Ridge 1	14311	106.98	20906	156.28
Ridge 2	10555	78.90	14433	107.89
Ridge 3	9955	74.42	14156	105.82
Ridge 4	9774	73.06	15207	113.68
Ridge 5	11066	82.72	17125	128.02
Ridge 6	14448	108.00	21989	164.38
Cairn 013	3706	27.70	2106	15.74
Cairn 014	445	3.33	79	0.59
Cairn 015	3728	27.87	4045	30.24
Cairn 016	7721	57.72	10744	80.32

Ridge 6 (Fig 6.41) and Ridge 1 (Fig 6.42) have the next largest projective and reflective viewsheds, and are quite similar to each other in both size and appearance. Many of the same areas of landscape, archaeological sites and landscape features are visible from Ridge 6 and Ridge 1, as were visible from cairn III and the other cairns on Stelae Ridge south.

The viewsheds for Ridges 2–5 are all smaller than those of Ridge 1 and Ridge 6, although their viewsheds do intersect with many of the same landscape features (Fig 6.43–Fig 6.46). It is notable that Ridge 1, Ridge 6 and Stelae Ridge are to the east of the main mining area, while the other ridges with smaller viewsheds are to the south and west (Fig 6.40), suggesting that the particular topography of the landscape ensured the ridges to the east of the main mining area had the best visibility.

The four surviving or partially surviving cairns 013–016 all have limited viewsheds (Fig 6.47–Fig 6.50), which are noticeably smaller than the viewsheds for the ridges. Cairn 016 has the largest viewsheds of all the cairns (Fig 6.47), but many areas which were visible to Stelae Ridge and the other ridges were not visible to cairn 016, including significant parts of the routes south-east towards the Gebel el-Asr and south-west towards Quartz Ridge.

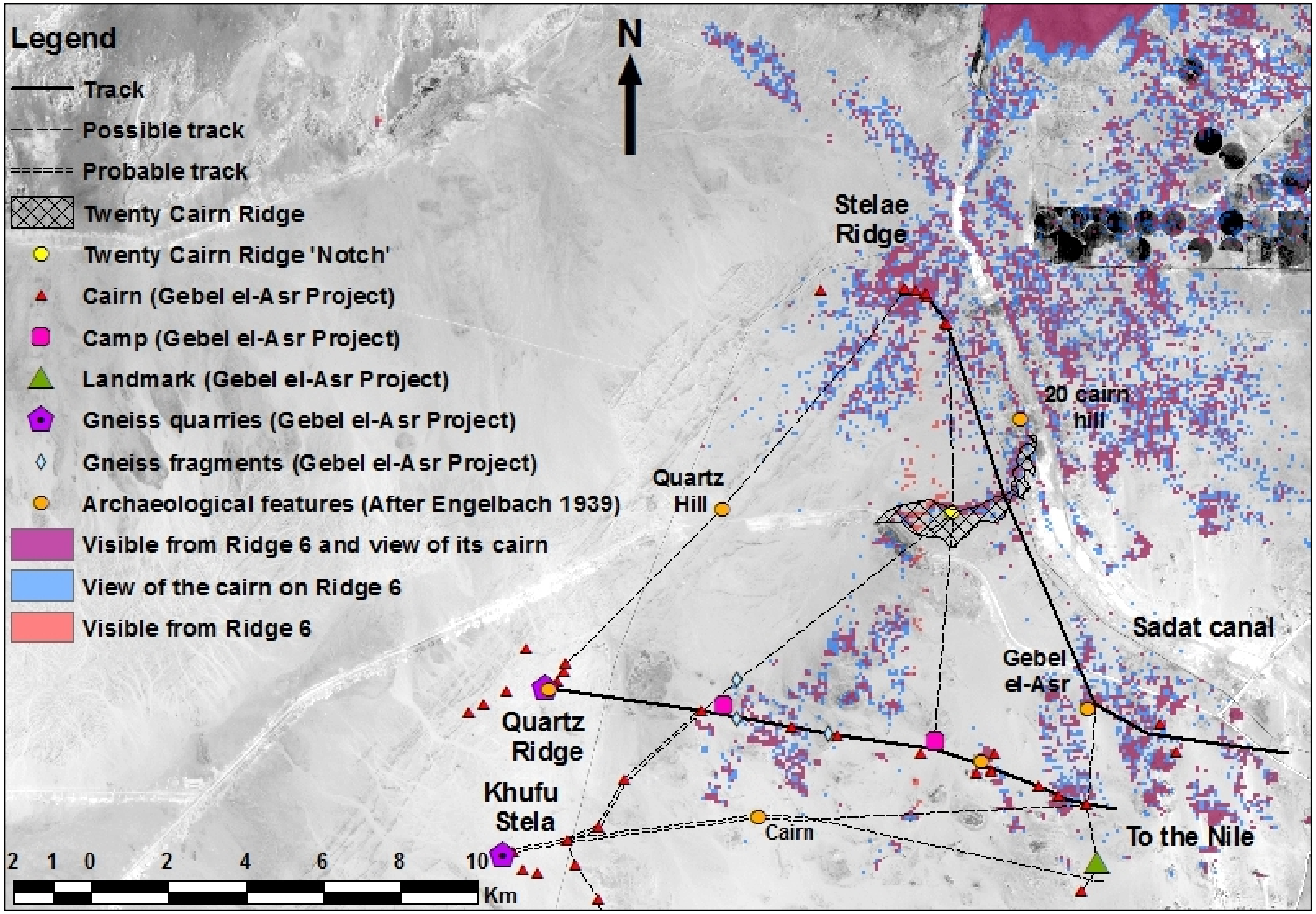


Fig 6.41: Projective and reflective viewsheds for Ridge 6, showing what was visible from the ridge and where a cairn on it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

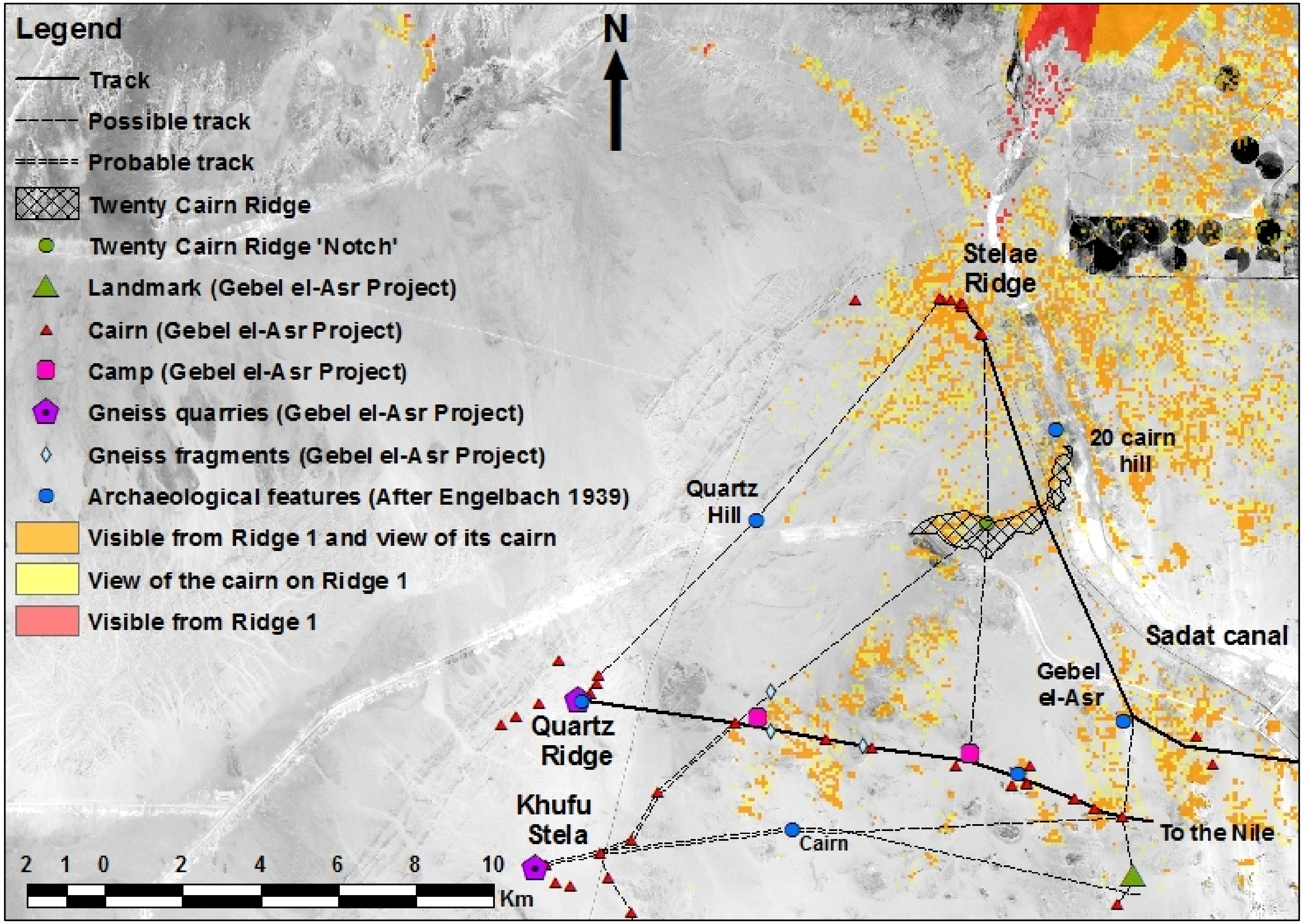


Fig 6.42: Projective and reflective viewsheds for Ridge 1, showing what was visible from the ridge and where a cairn on it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

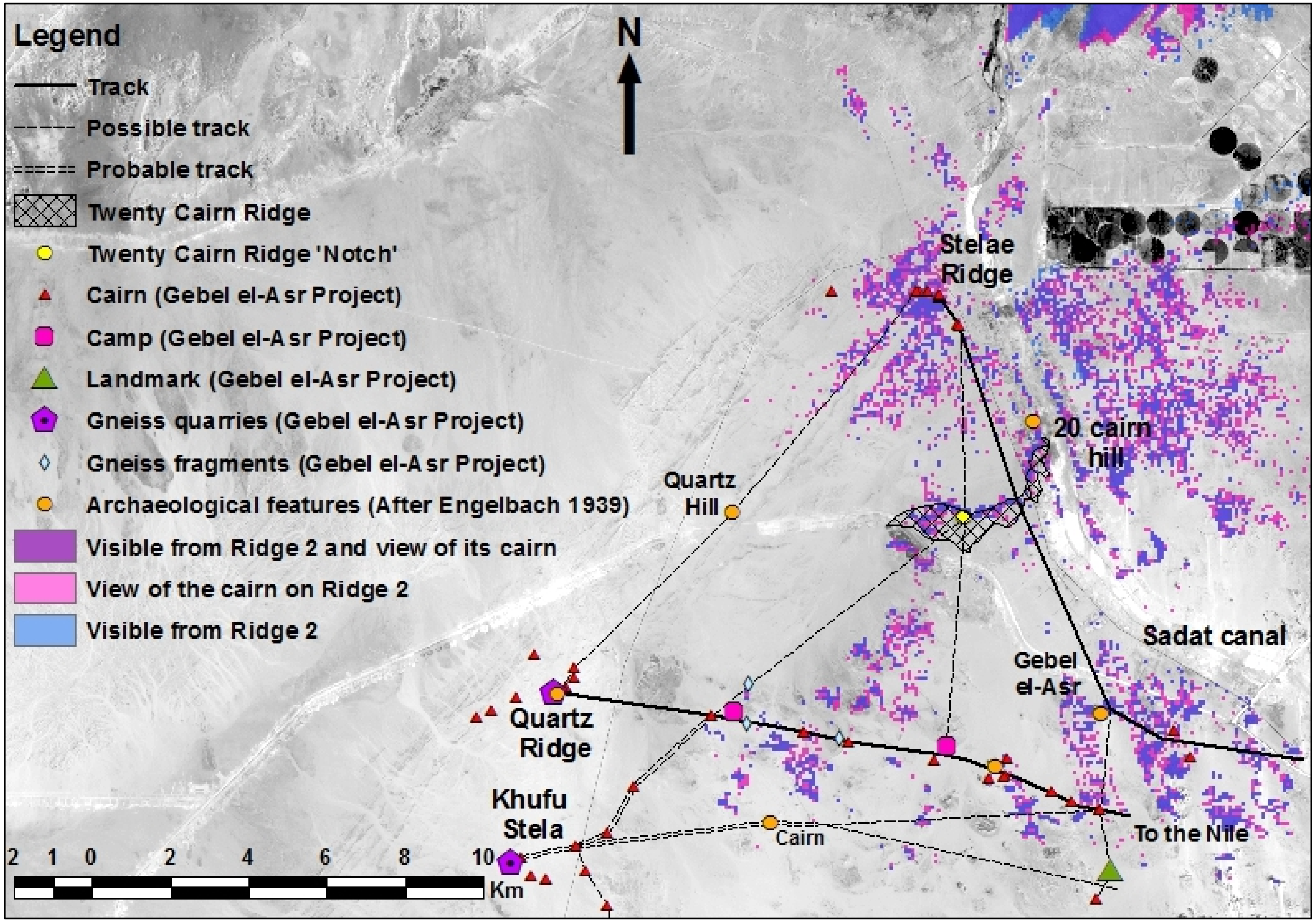


Fig 6.43: Projective and reflective viewsheds for Ridge 2, showing what was visible from the ridge and where a cairn on it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

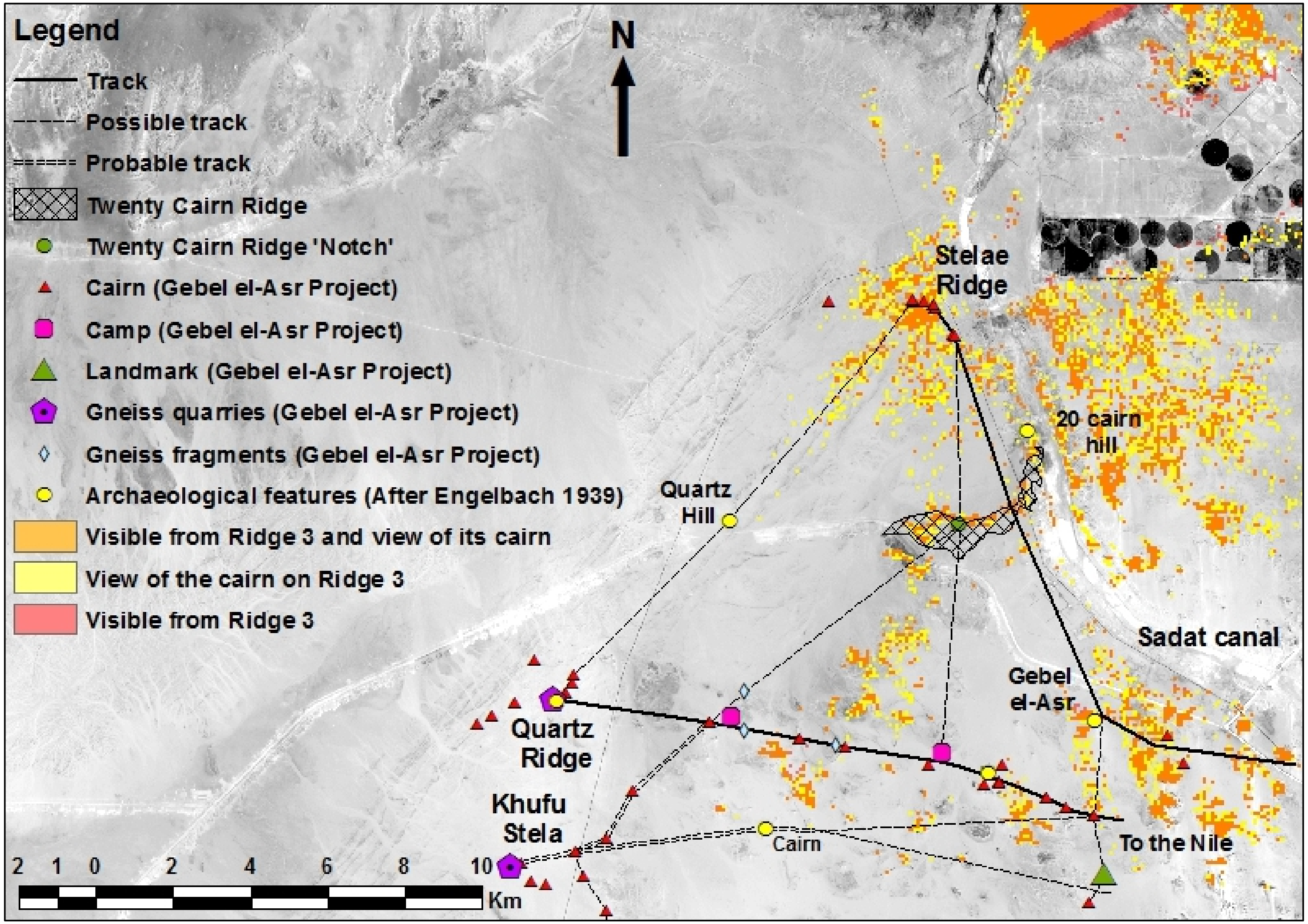


Fig 6.44: Projective and reflective viewsheds for Ridge 3, showing what was visible from the ridge and where a cairn on it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

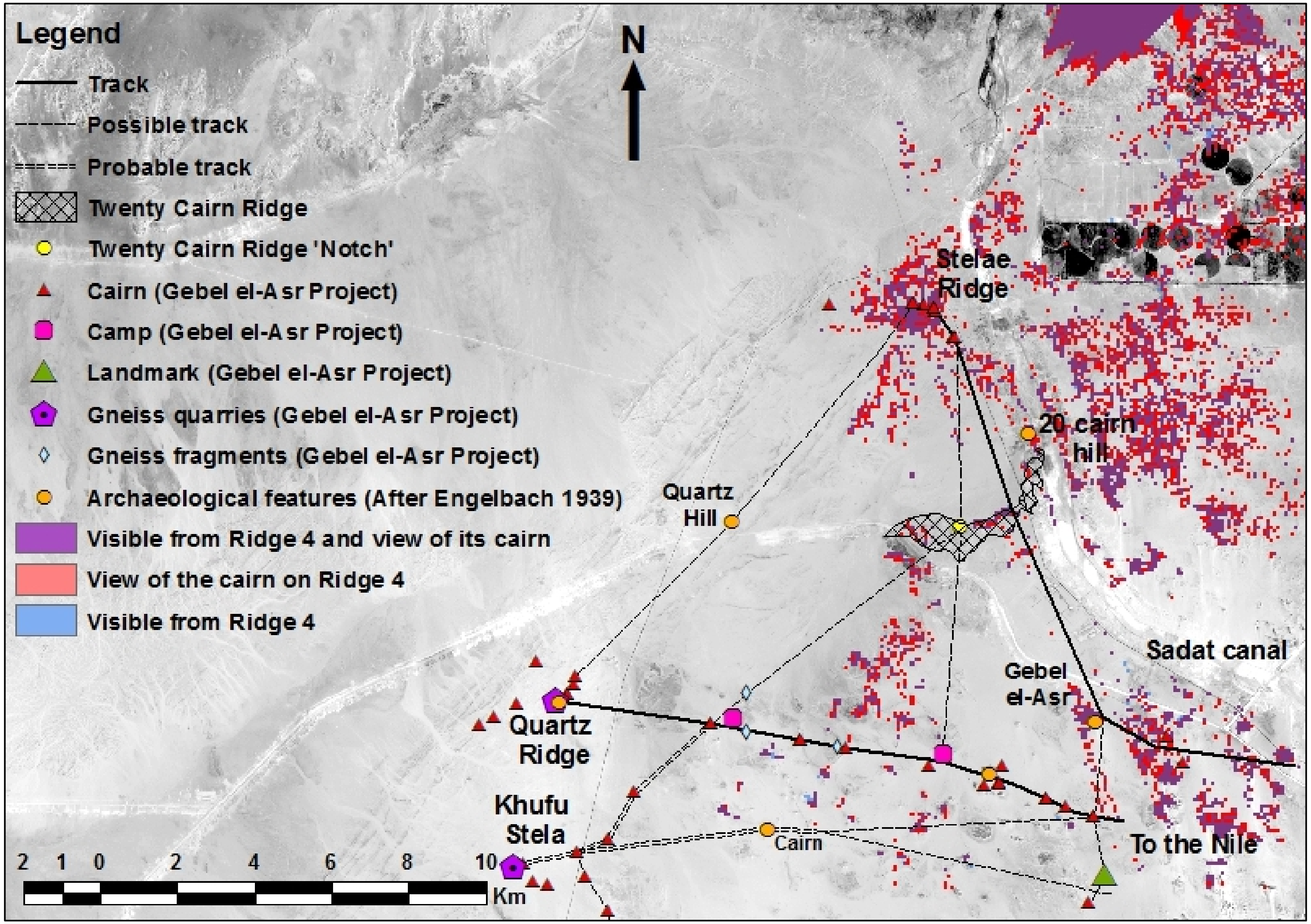


Fig 6.45: Projective and reflective viewsheds for Ridge 4, showing what was visible from the ridge and where a cairn on it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

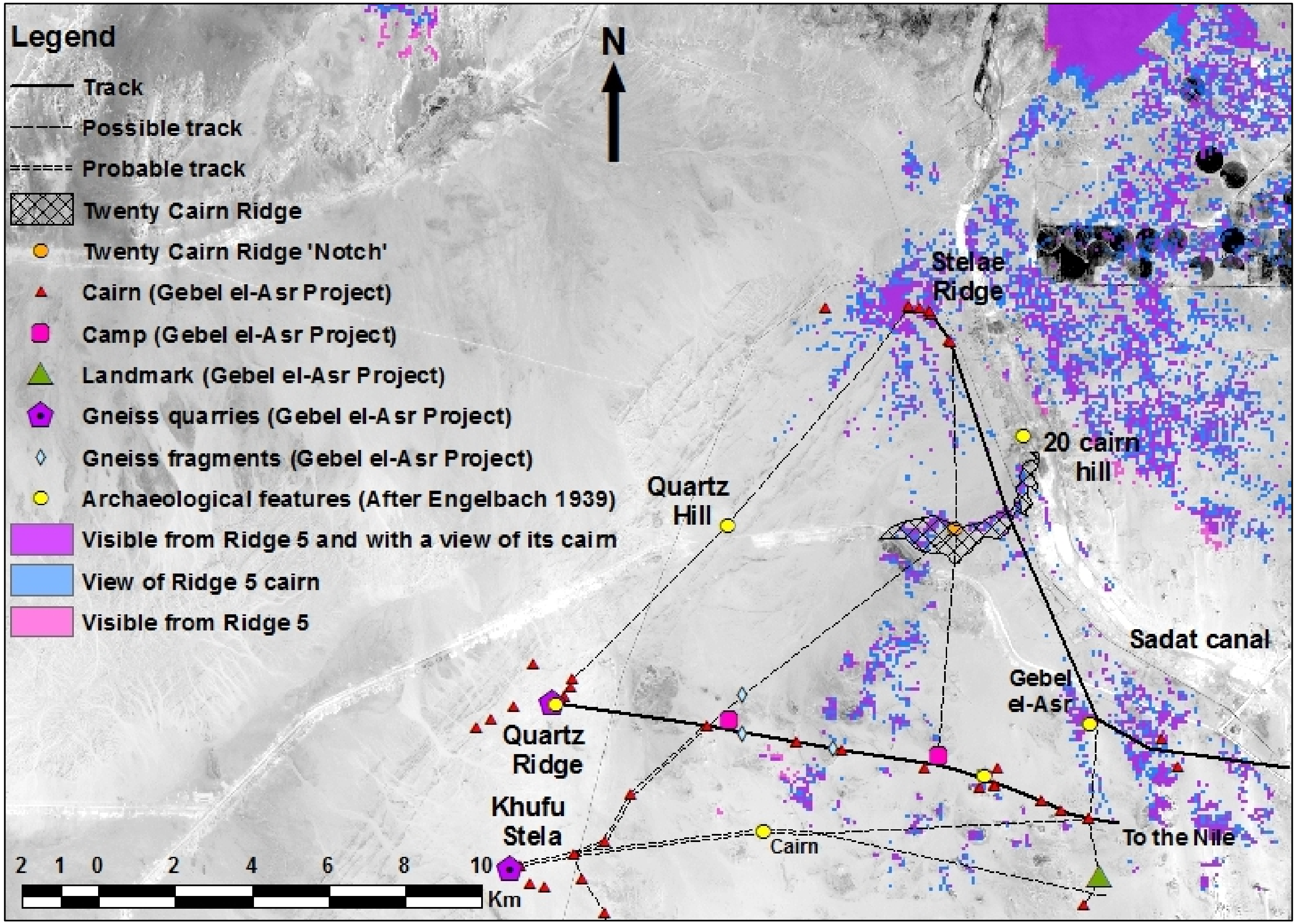


Fig 6.46: The projective and reflective viewsheds for Ridge 5, showing what was visible from the ridge and where a cairn on it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

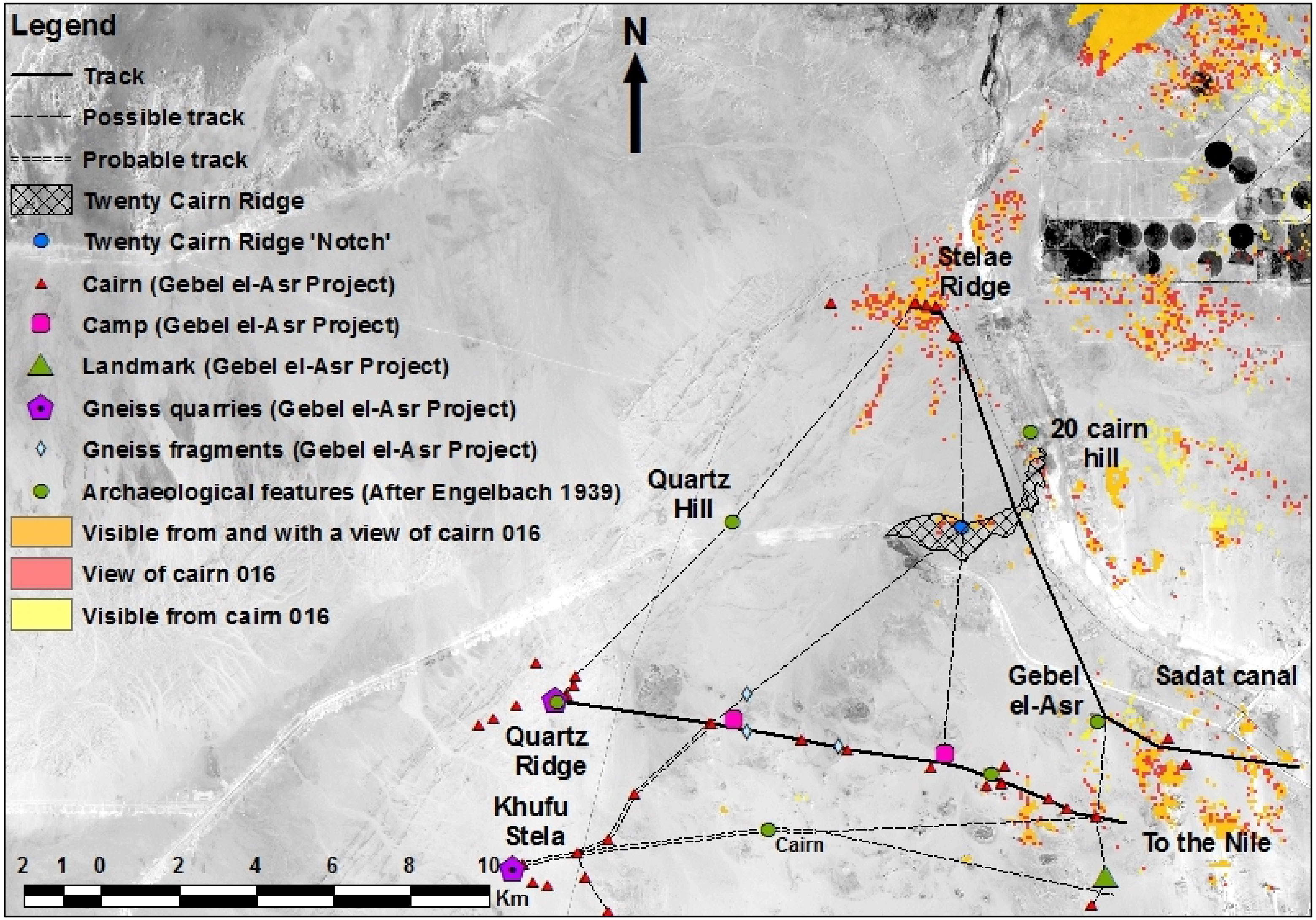


Fig 6.47: The projective and reflective viewsheds for cairn 016, showing what was visible from the cairn and where it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

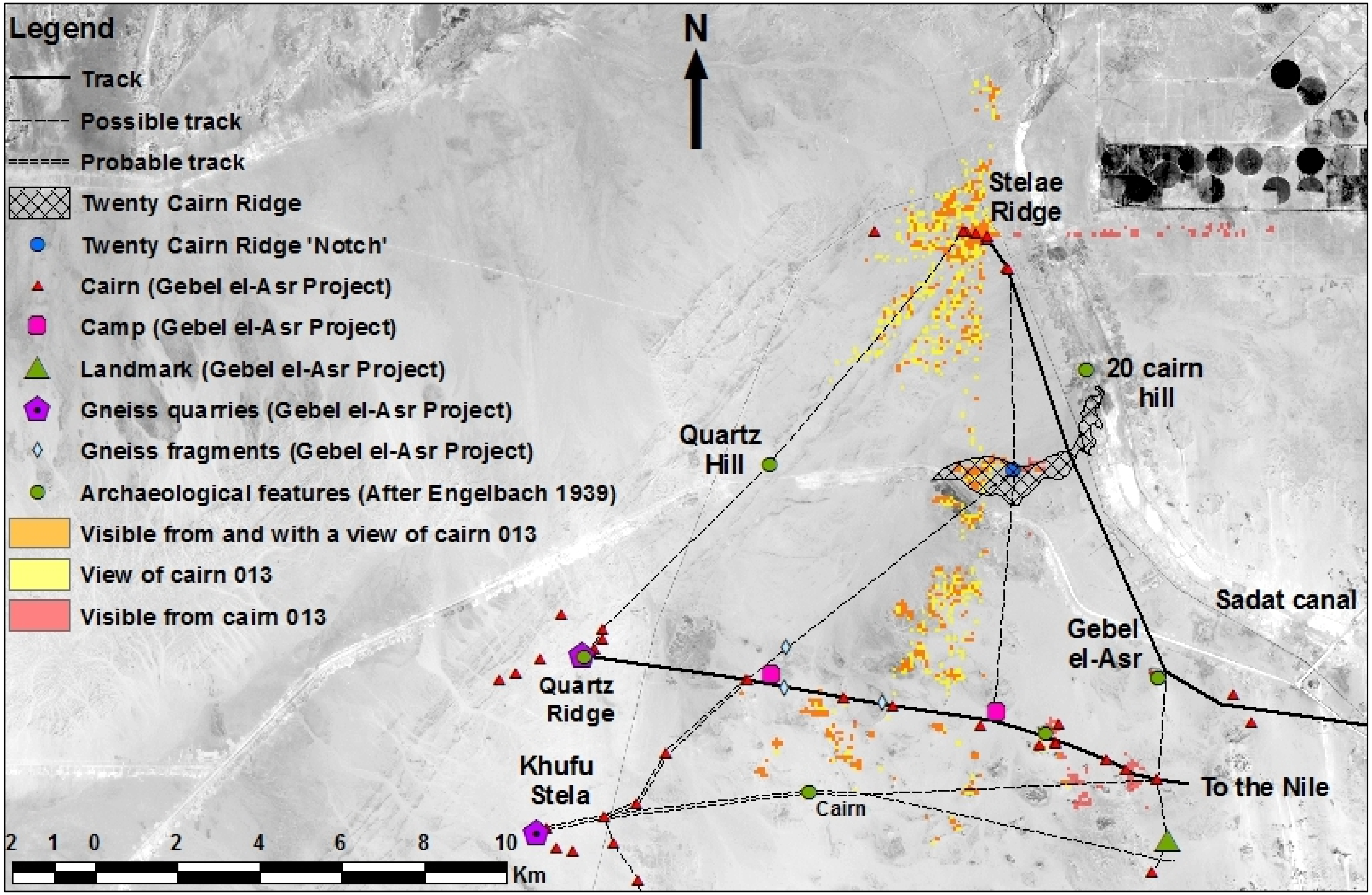


Fig 6.48: The projective and reflective viewsheds for cairn 013, showing what was visible from the cairn and where it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS).

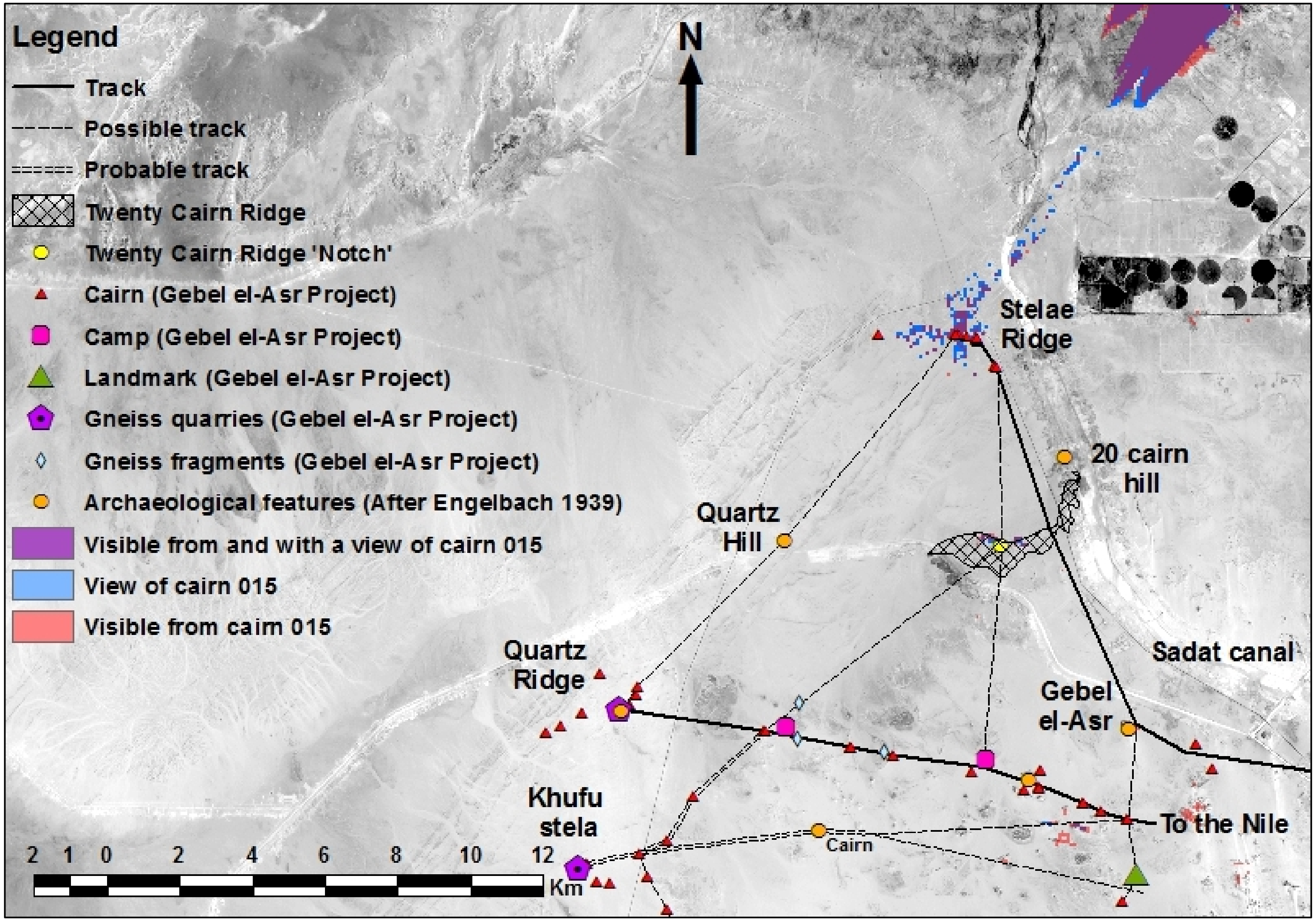


Fig 6.49: The projective and reflective viewsheds for cairn 015, showing what was visible from the cairn and where it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS)

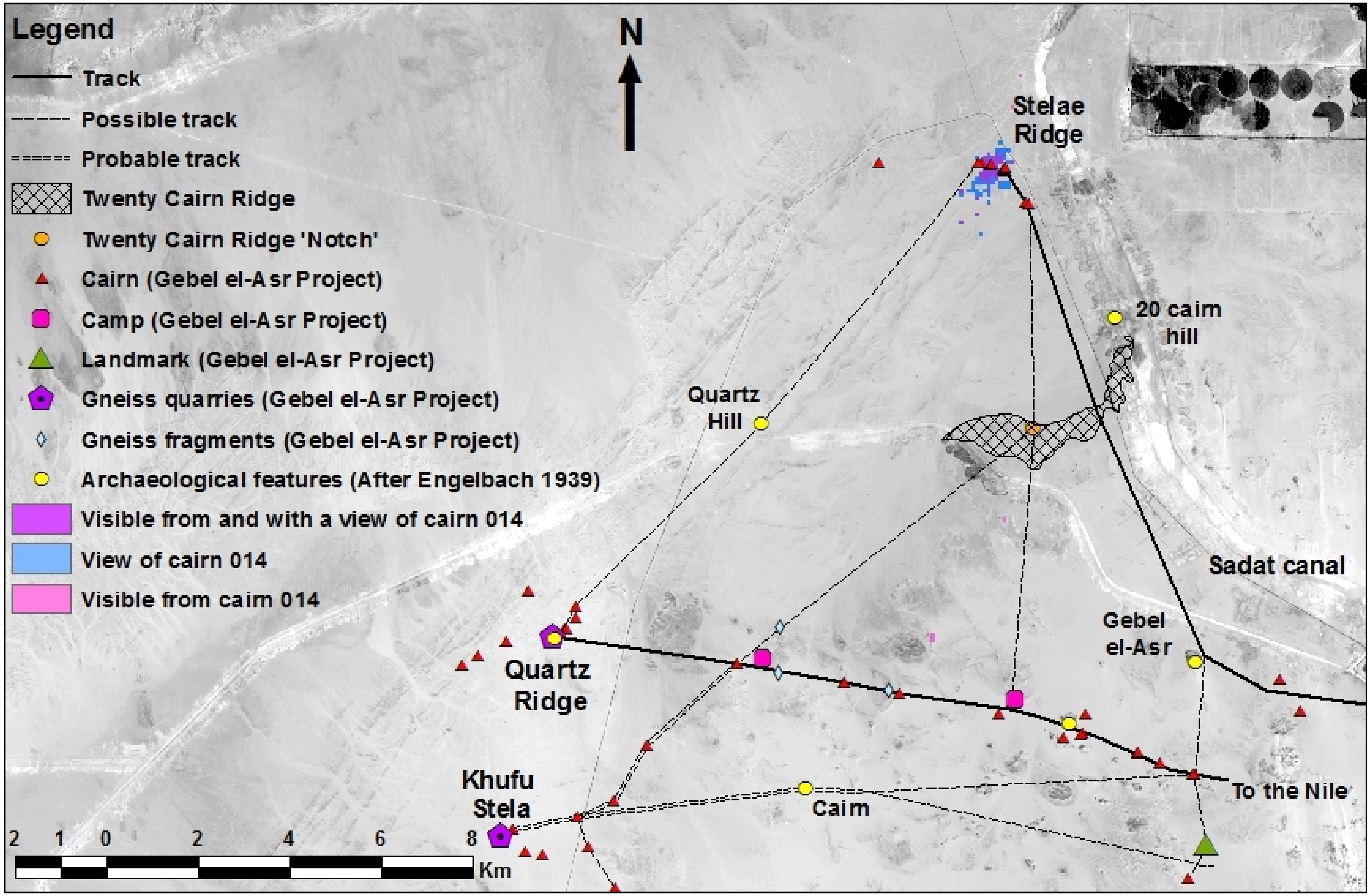


Fig 6.50: The projective and reflective viewsheds for cairn 014, showing what was visible from the cairn and where it would be visible, overlying the panchromatic band (8) of Landsat 8 imagery from 2013. (Satellite imagery from USGS).

Cairn 013 was badly demolished in modern times, but is the only cairn not on Stelae Ridge which is known to have produced any artefacts. A stela of Amenemhat II and a carnelian earring were found near it by the Gebel el-Asr Project (Shaw *et al.* 2010, 302). Its viewsheds (Fig 6.48) are slightly better than cairn 014. Its projective viewshed is of a similar size to cairn 015, but its reflective viewshed is just over half the size of cairn 015's, meaning it would have been much less visible. Unlike cairn 015 it is not on a ridge, but in a relatively low area. It would not have been as effective a landmark as cairns on the six alternative ridges or Stelae Ridge itself. This confirms that later in the development of Stelae Ridge, presumably by the reign of Amenemhat II, visibility was not an important factor in the location of cairns with artefacts, otherwise cairn 013 would have been situated in a position with better visibility.

Cairn 015 is barely visible from the south at all (Fig 6.49) and would only have been an effective landmark for those already around the Stelae Ridge area. The same is true of cairn 014, which has the smallest viewshed of all and is only inter-visible with a small area around Stelae Ridge (Fig 6.50). It would have made a poor landmark, although like cairns 015 and 016 it is well situated to mark the position of the large mine and main mining area to those who had already reached the area or were working on its periphery.

Overall, the visibility of cairns 013–016 is very limited in comparison to Stelae Ridge and the other ridges. Of the alternative ridges, those to the east of the main mining area had better views and were more visible than those to the south and west. Stelae Ridge was undoubtedly more visible to the landscape and had better views of it than any of the alternatives tested here. This suggests that Stelae Ridge was deliberately chosen because it had good views and was very visible, reinforcing the conclusion that the earliest structures on it functioned as landmarks and the site was chosen because of its suitability for this purpose.

Quite how the superiority of Stelae Ridge over the other ridges was determined is a different question. It may be that several different ridges were considered and perhaps cairns were built on them in a process of trial and improvement. Alternatively the builders may have relied upon the greater height of Stelae Ridge, which was 1m higher than the next highest alternative, or they may have identified suitably visible ridges when approaching the site.

6.5.2. Visibility of the mining area from alternative ridges and cairns

The projective and reflective viewsheds of each of the alternative ridges were examined to assess how visible the main mining area was from them and how visible any cairn on these ridges was to individuals in the mining area. As in the previous section, the projective visibility analysis of OB3 without azimuths and the reflective visibility analysis of cairn III represented Stelae Ridge (Fig 6.51).[333]

Fig 6.52–Fig 6.57 show the views from Ridge 1 to Ridge 6 and where any cairns on those ridges would be visible, with specific reference to the mining area. Fig 6.58–Fig 6.61 show the views from cairns 013–016 and where they would be visible. Although the visibility from the different ridges is quite similar, Stelae Ridge, represented by cairn III is slightly more visible from the mining area. Visibility of the mining area from OB3 is slightly less than or equal to visibility of the mining area from the alternative ridges; OB3 has less of the view of the main mining area than Ridges 1–3, and a roughly equal view to Ridges 4–6, allowing for the low resolution of the SRTM. OB3 undoubtedly has less of a view of the main mining area than cairns 013–016.

Stelae Ridge, as represented by cairn III and OB3, was a slightly better location for a highly visible cairn and a secluded court than the alternative ridges. Although it is worth remembering that OB3 was not actually located in a court and the other cairn-courts may have had slightly different views, there is not a lot of difference between the viewsheds of OB3 and the other ridges in respect of their views of the main mining area. Furthermore the construction of strategically placed cairns between the putative courts and the view over the mining area could have dramatically reduced visibility of the mines at the alternative ridges, just as it did at Stelae Ridge. It is therefore likely that the view of the mining area from Stelae Ridge was not the defining factor in the choice of this location over the alternative ridges, although it may have made a minor, possibly accidental, contribution.

The viewsheds of cairns 015–016 support the conclusion that they were located to provide local landmarks for individuals in the mining area. The difference between the viewsheds for Ridges 1–6 and the viewsheds for cairns 015–016 are quite clear. While Stelae Ridge and the alternative ridges have limited inter-visibility with the area of the large mine and main mining area, these areas are almost completely inter-visible with cairn 015 and 016 (Fig 6.58 and Fig 6.59).

[333] It is not practical to use azimuths to model the impact of any potential cairn upon visibility analysis of ground level upon the alternative ridges or near other cairns in the area because the results would be heavily influenced by the location of the cairn in relation to the court. Since the location of any cairns or courts on these ridges is not known, it is not possible to create appropriate azimuths.

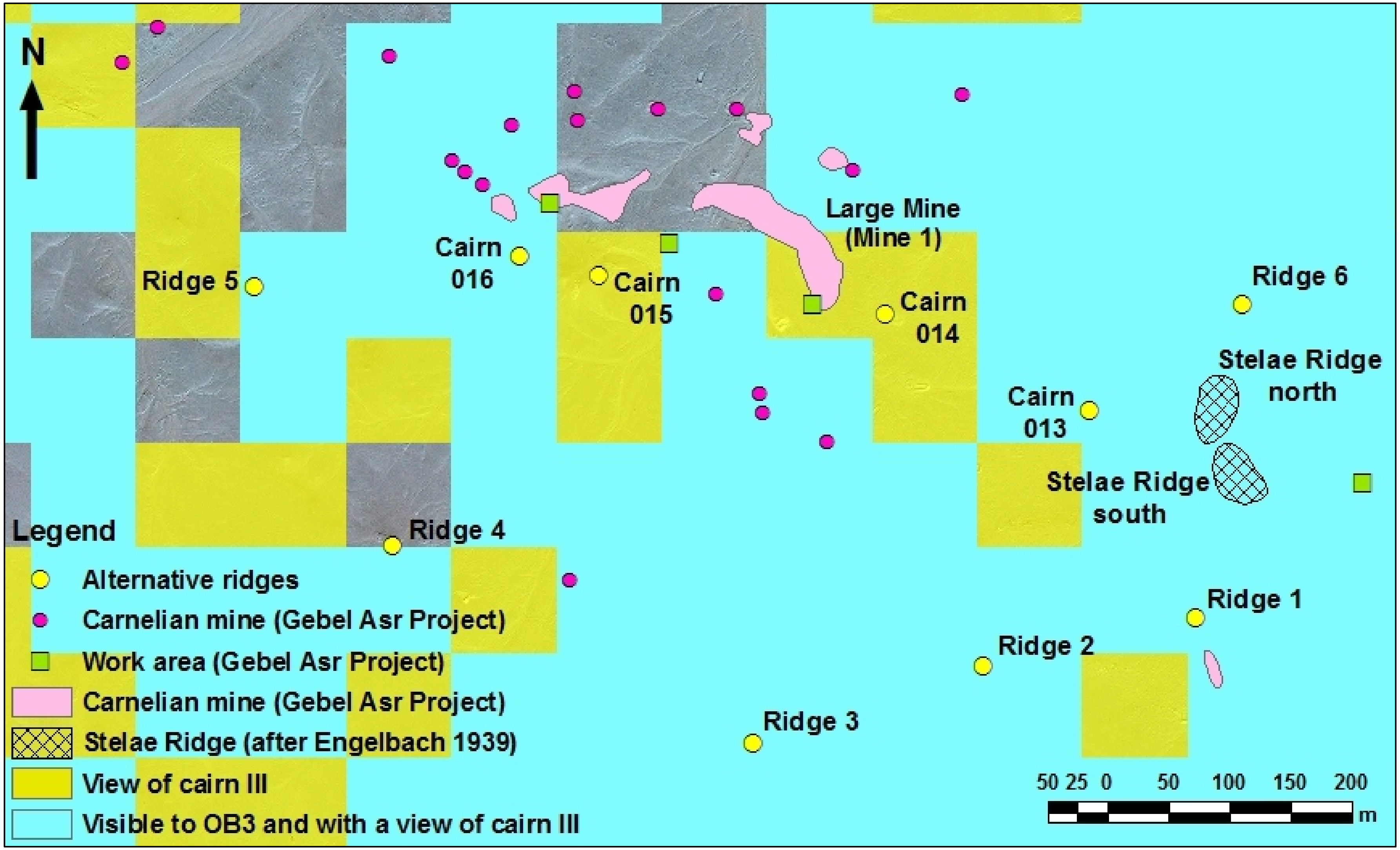


Fig 6.51: Projective and reflective viewsheds for OB3 and cairn III on Stelae Ridge south, showing what was visible from the ridge and where a cairn on it would be visible, displayed overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

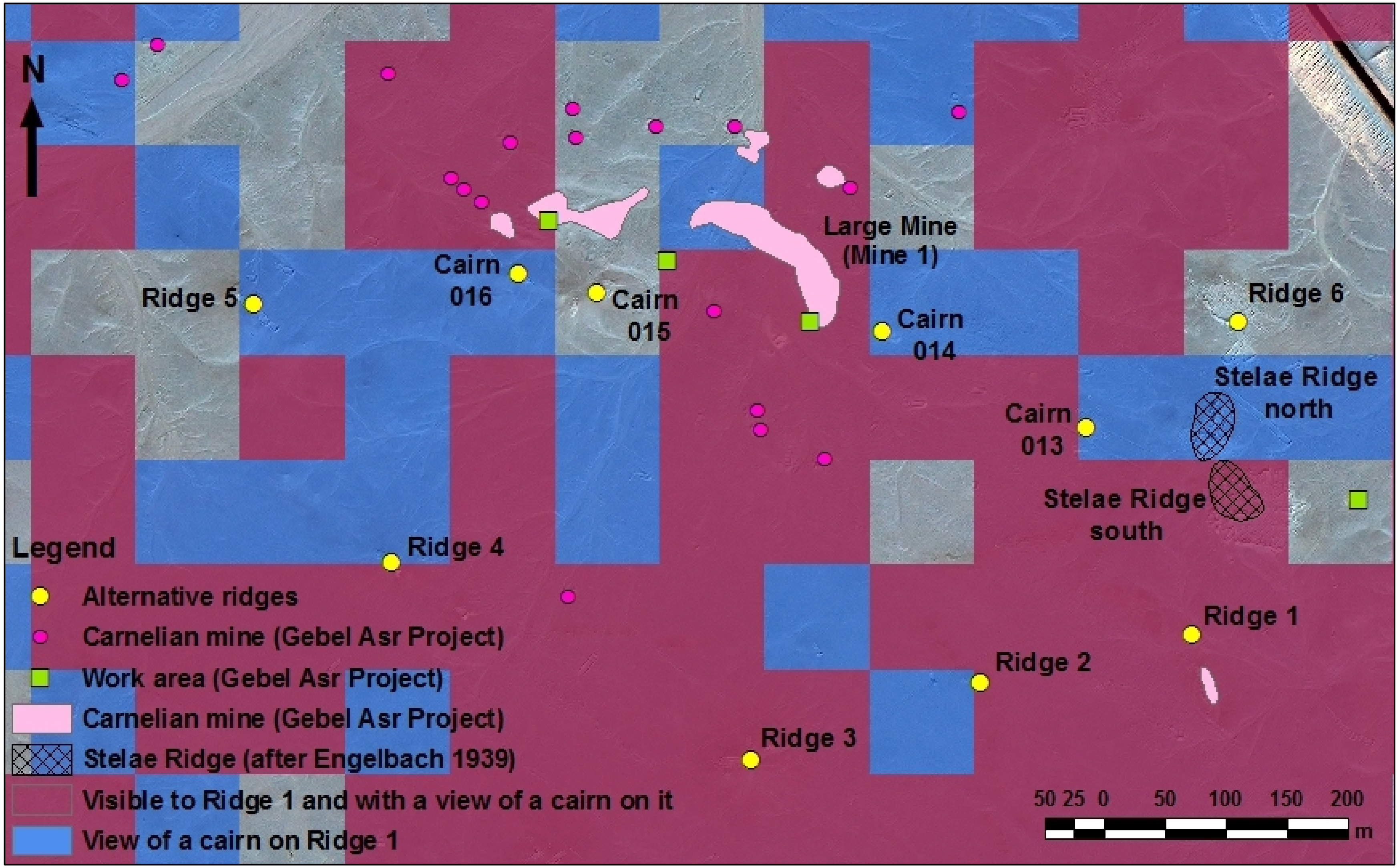


Fig 6.52: Projective and reflective viewsheds for Ridge 1, showing what was visible from the ridge and where a cairn on it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

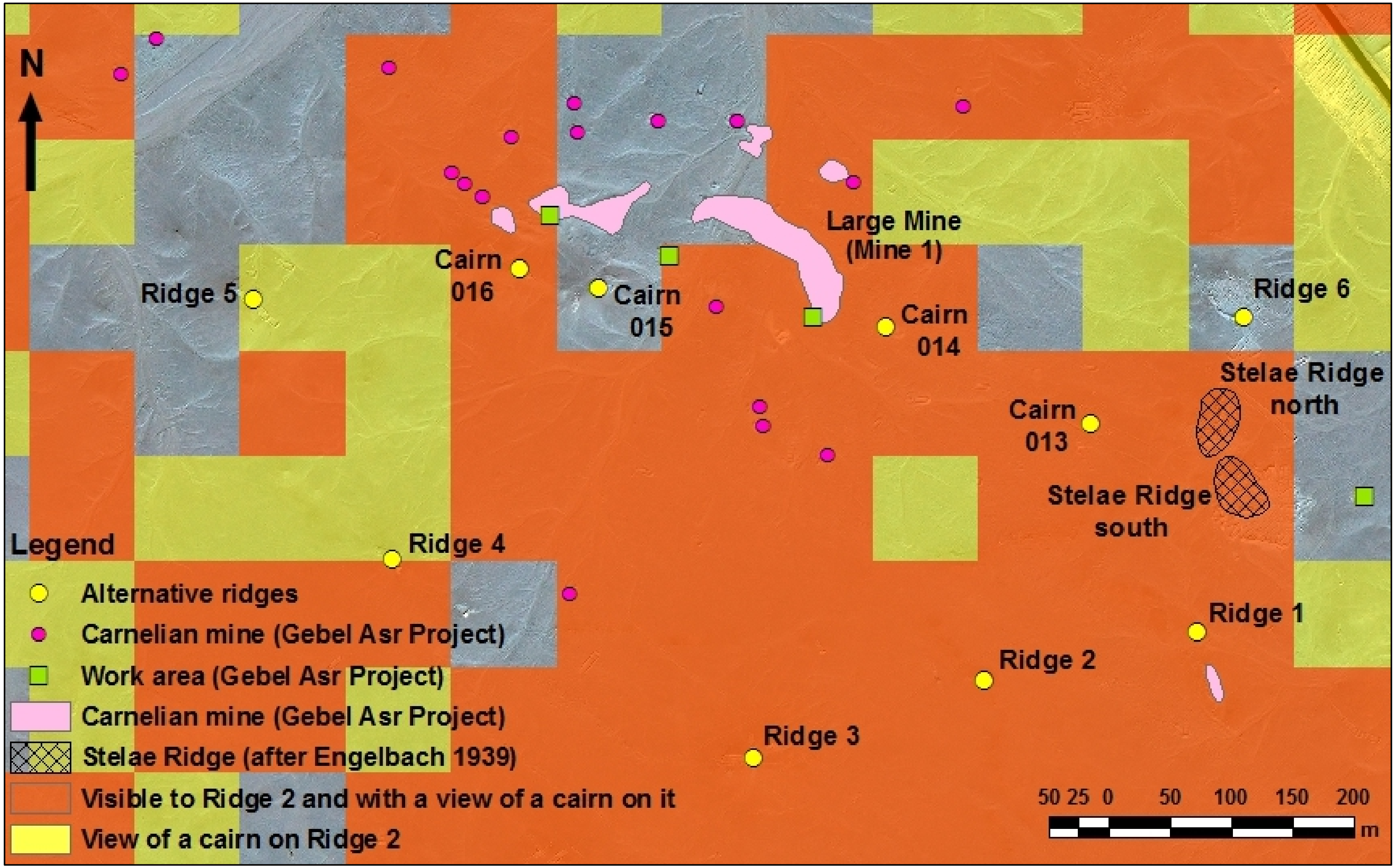


Fig 6.53: Projective and reflective viewsheds for Ridge 2, showing what was visible from the ridge and where a cairn on it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

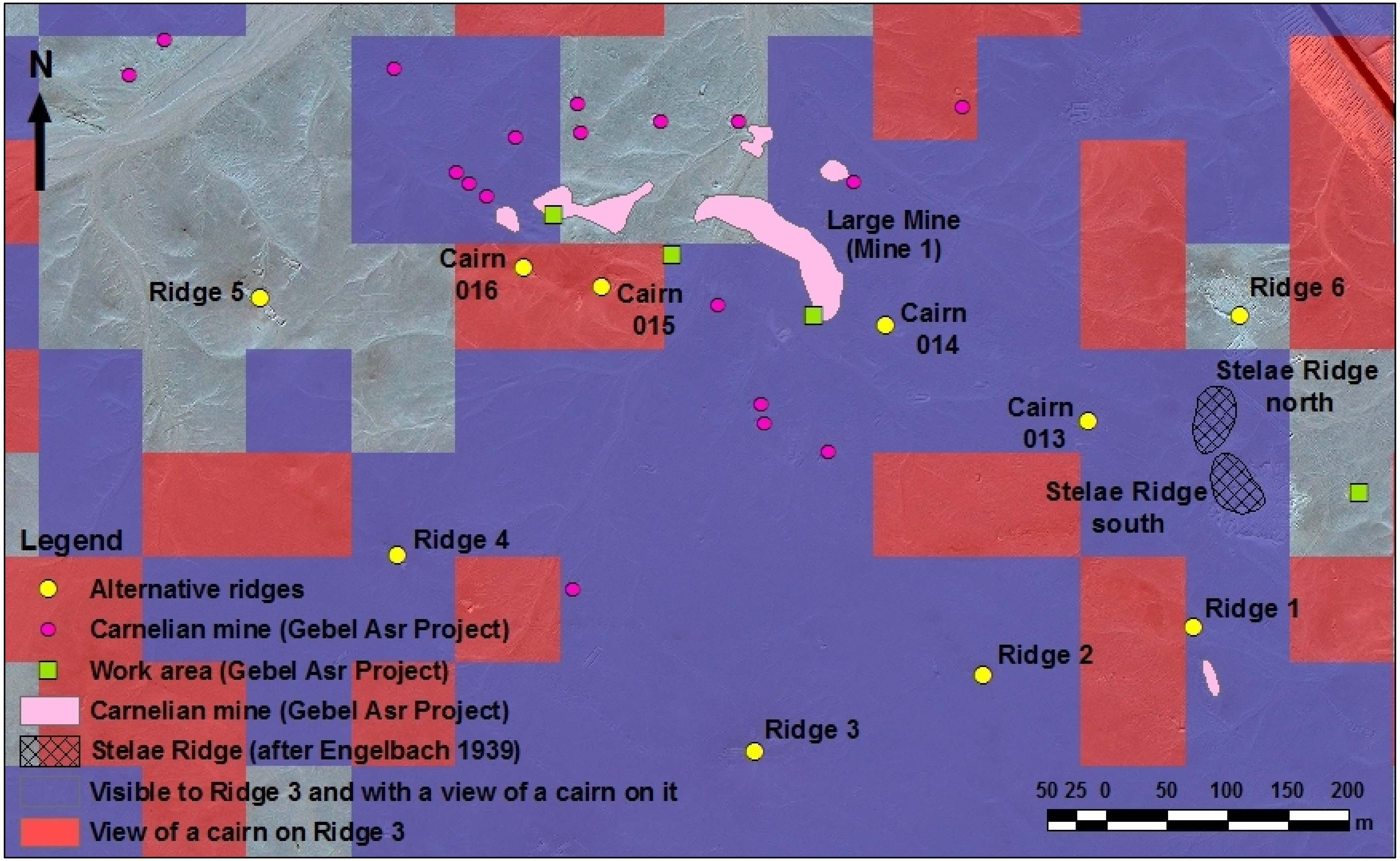


Fig 6.54: Projective and reflective viewsheds for Ridge 3, showing what was visible from the ridge and where a cairn on it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

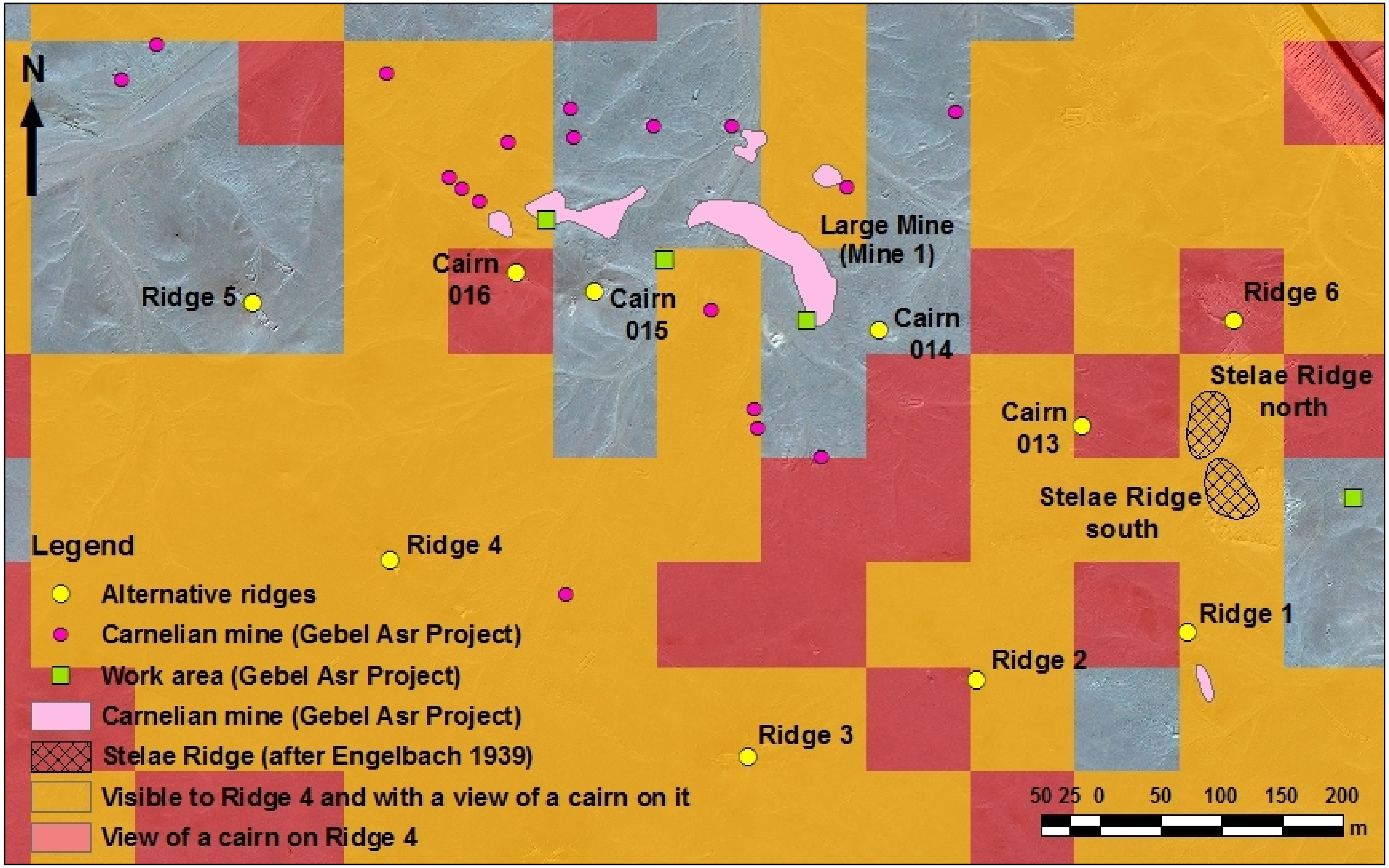


Fig 6.55: Projective and reflective viewsheds for Ridge 4, showing what was visible from the ridge and where a cairn on it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

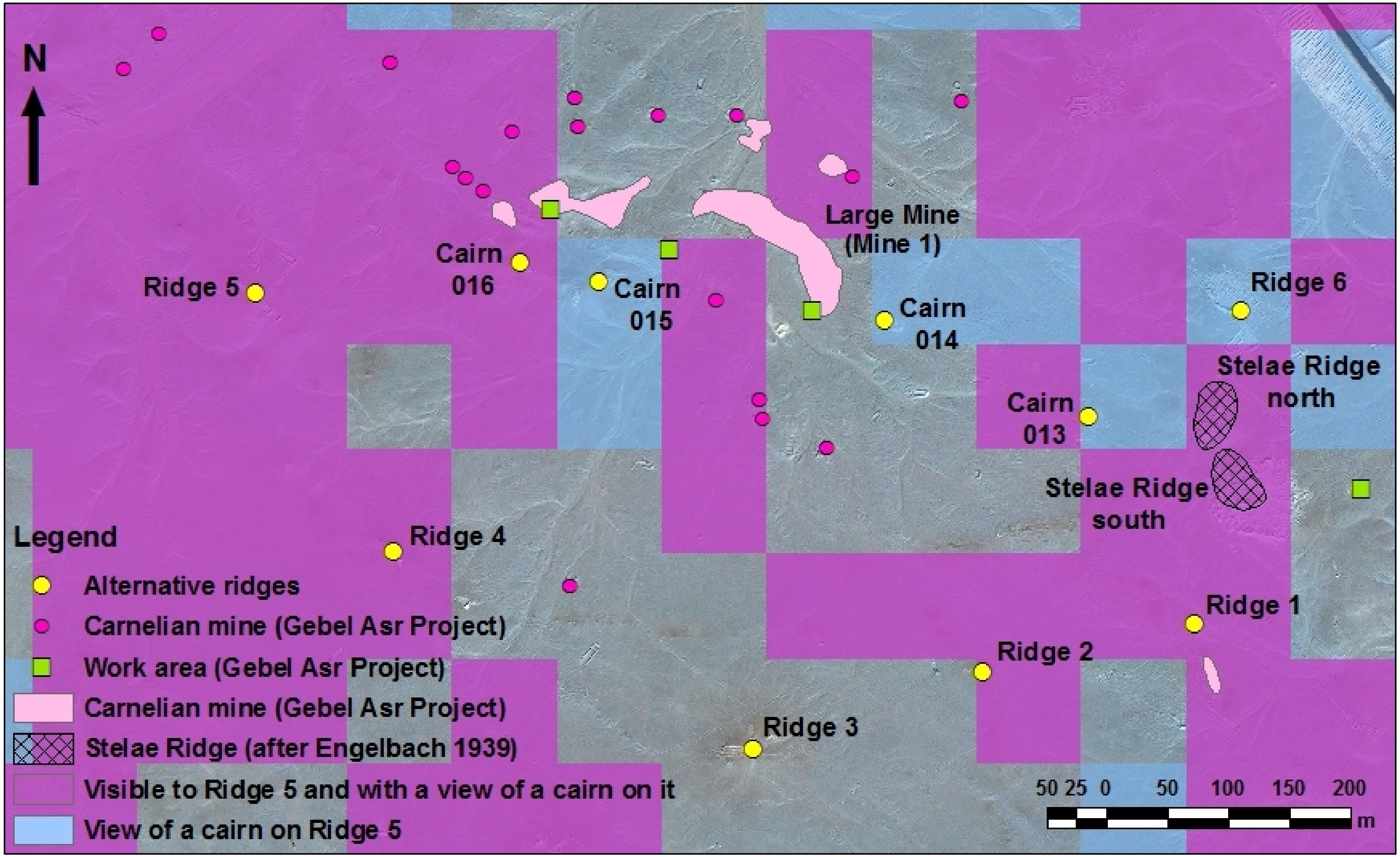


Fig 6.56: Projective and reflective viewsheds for Ridge 5, showing what was visible from the ridge and where a cairn on it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

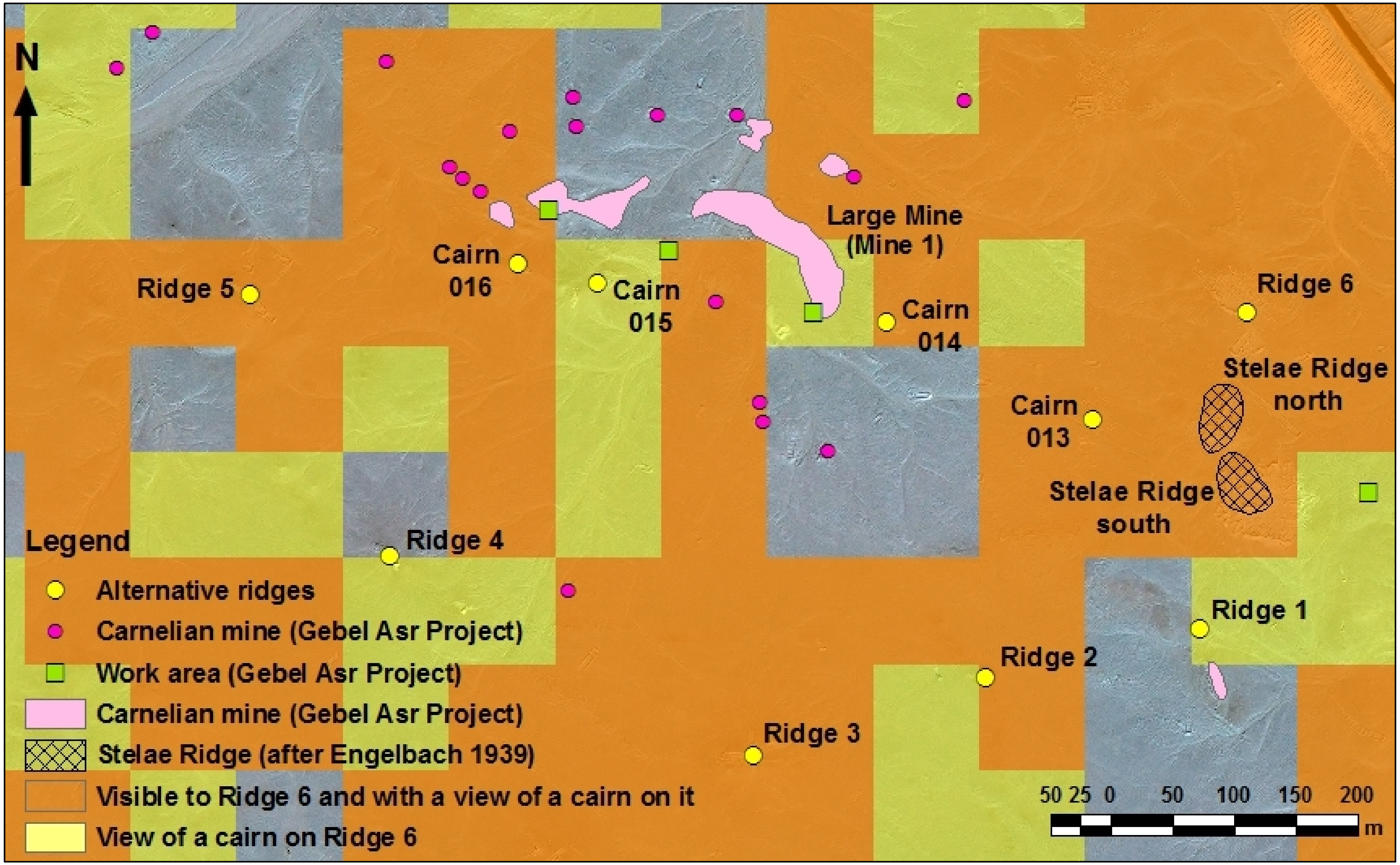


Fig 6.57: Projective and reflective viewsheds for Ridge 6, showing what was visible from the ridge and where a cairn on it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

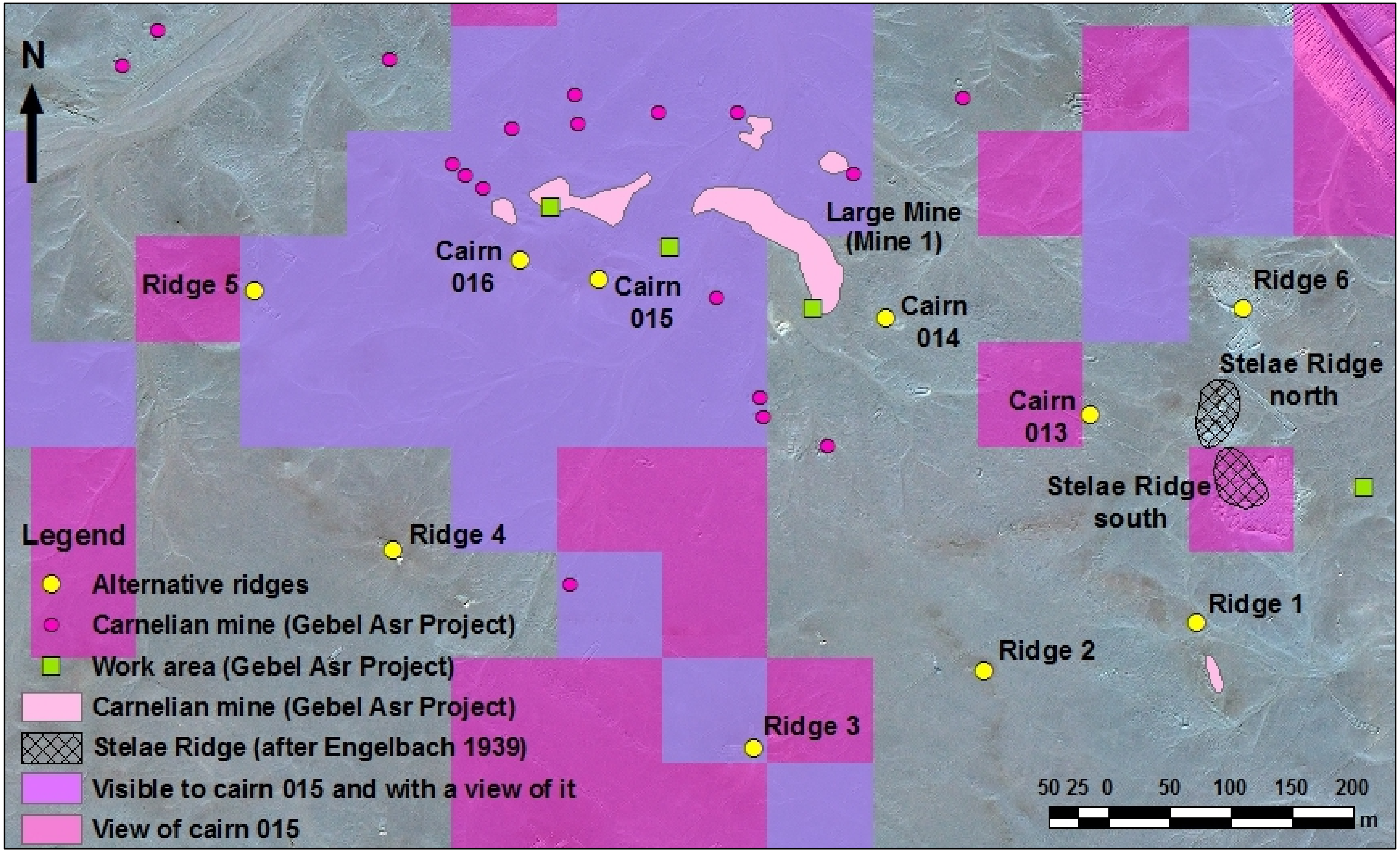


Fig 6.58: Projective and reflective viewsheds for cairn 015, showing what was visible from the cairn and where it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

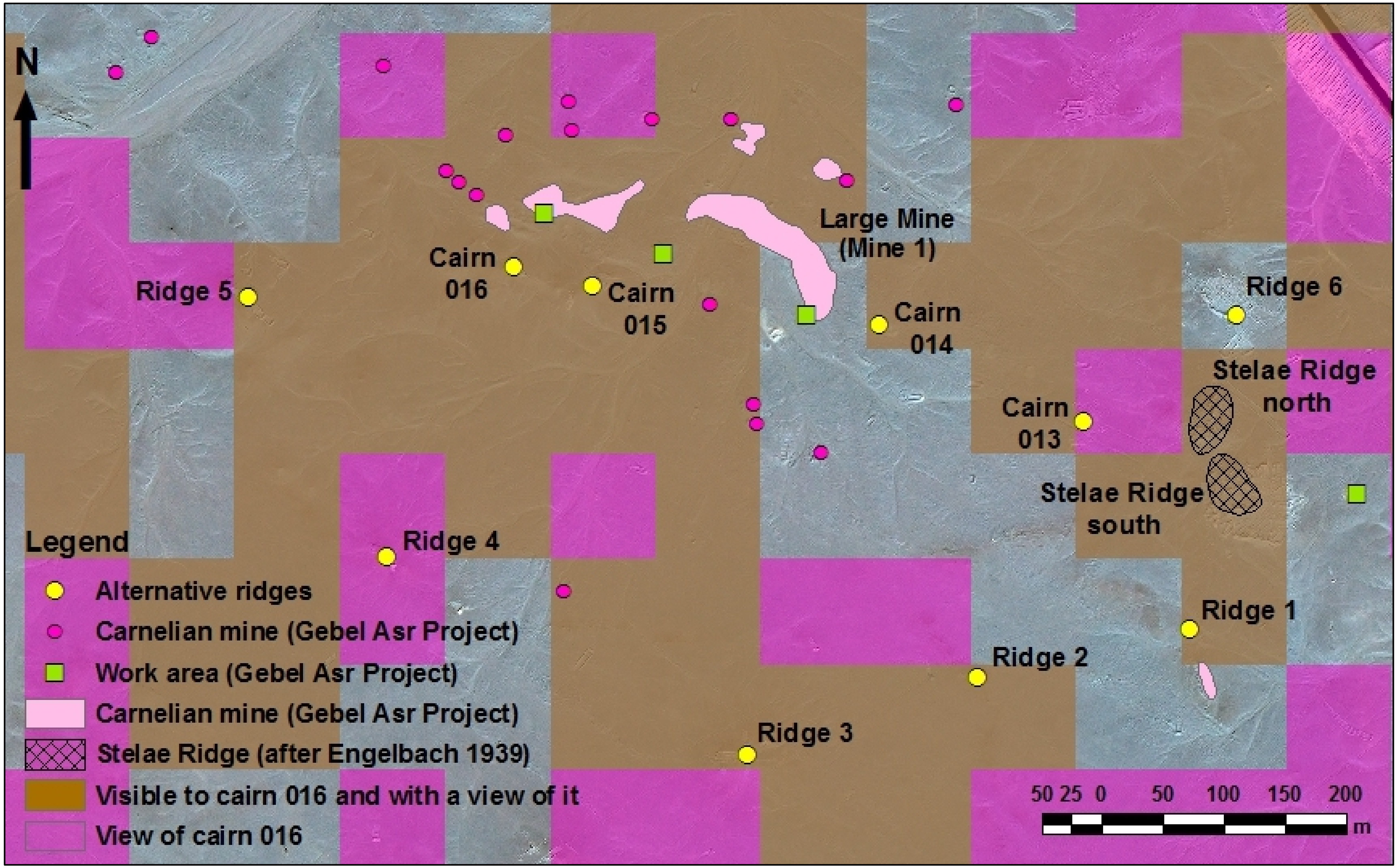


Fig 6.59: Projective and reflective viewsheds for cairn 016, showing what was visible from the cairn and where it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

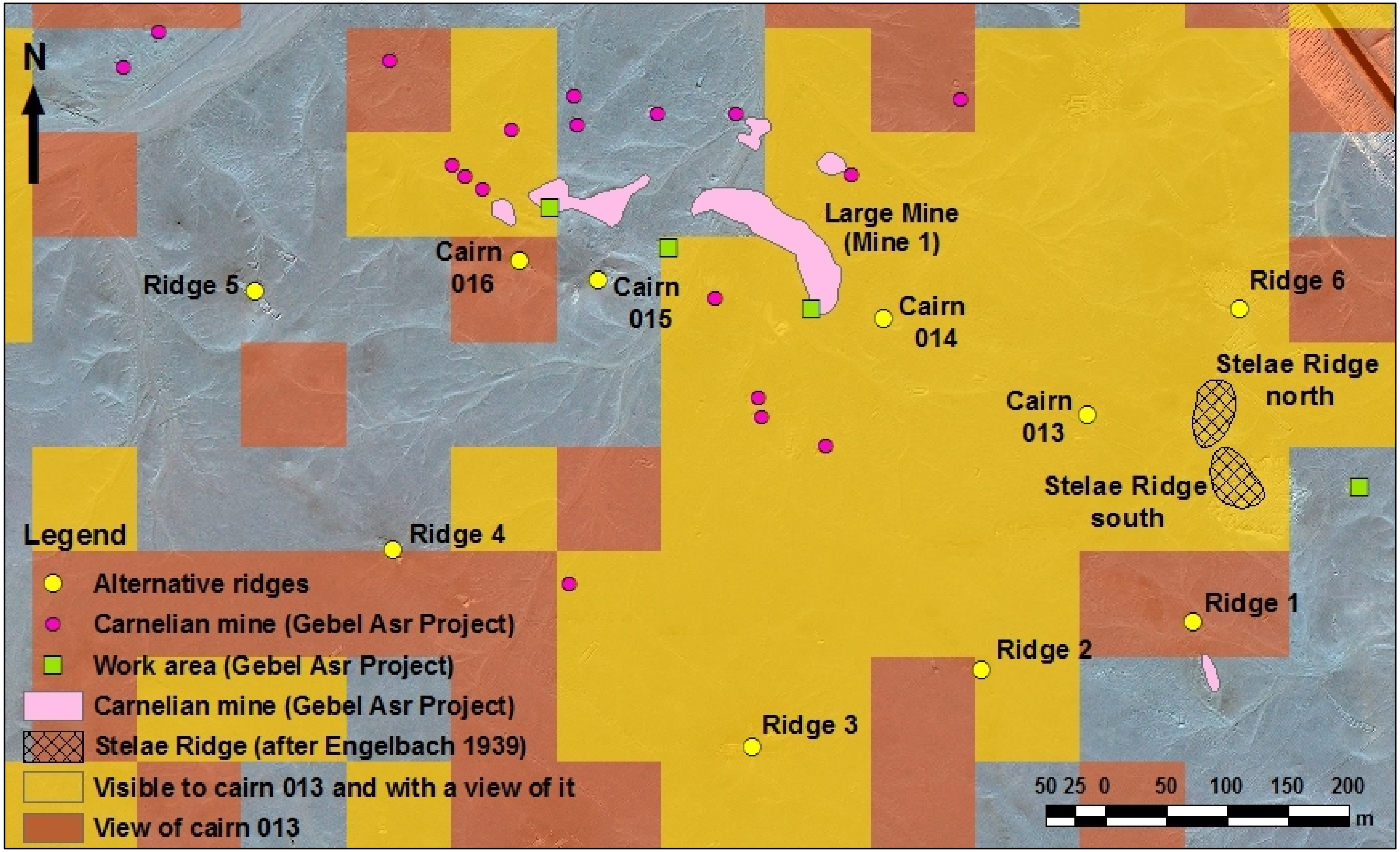


Fig 6.60: Projective and reflective viewsheds for cairn 013, showing what was visible from the cairn and where it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

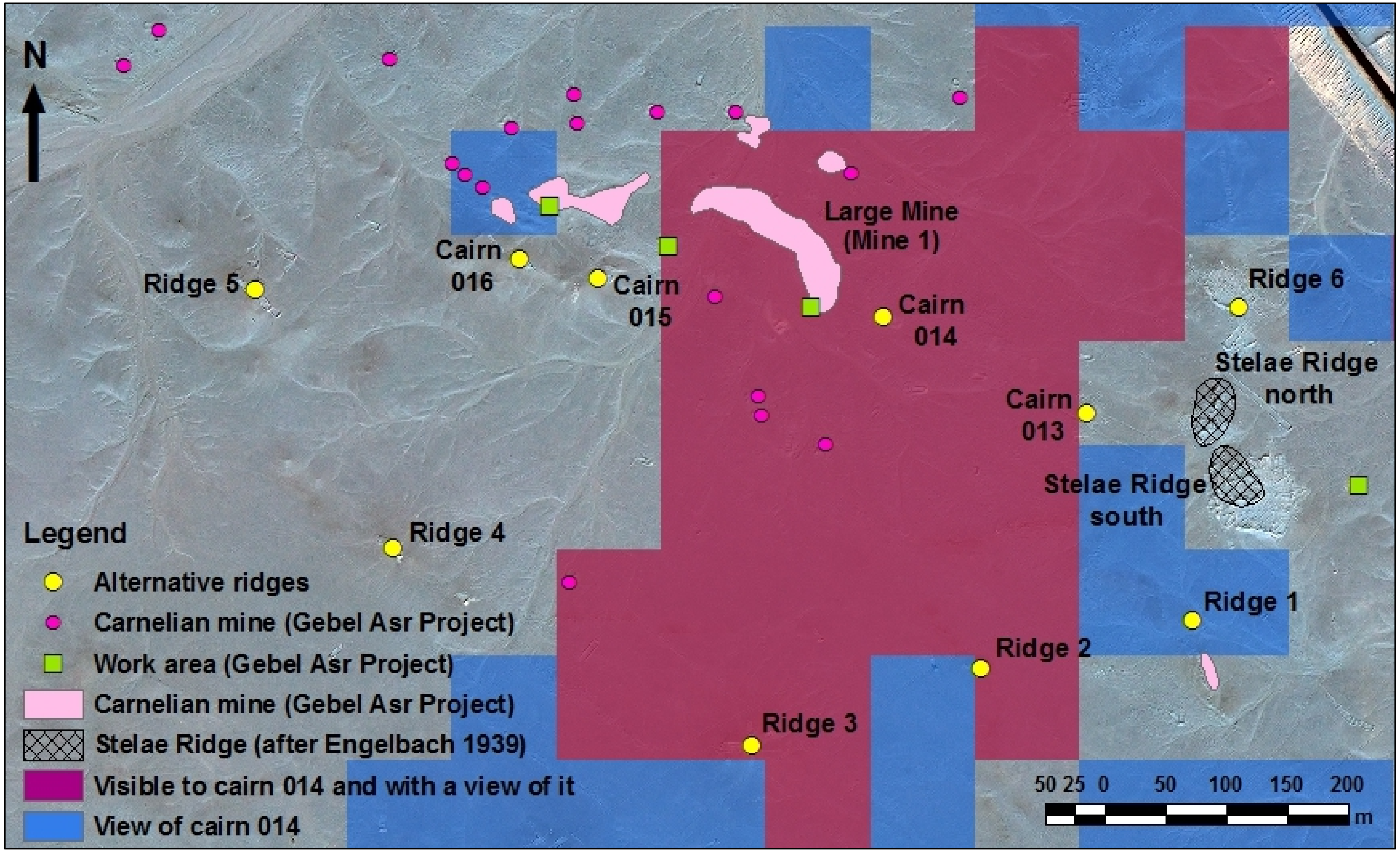


Fig 6.61: Projective and reflective viewsheds for cairn 014, showing what was visible from the cairn and where it would be visible. Viewsheds and features shown overlying the Quickbird image (Satellite image © European Space Imaging / Digitalglobe).

Cairns 013 and 014 (Fig 6.60 and Fig 6.61) are not inter-visible with the western part of the large mine or the area to the west of it, but they are inter-visible with the eastern part of the large mine and Stelae Ridge. In the case of cairn 014, this could support the conclusion that it was a very local marker, referring to the eastern end of the large mine. Although a large feature on the map, the large mine is not particularly visible in the landscape because it is almost at ground level and is the same colour as the rest of the desert. Fig 6.62 shows the view looking westwards from Stelae Ridge towards the large mine and the ridge with cairns 015 and 016. The large mine is behind and to the right of cairn 014, but the picture shows how it disappears into the background even on a clear day. On a hazy day or during the much reduced visibility of a sandstorm, cairn 014 could have provided a much needed landmark for those moving between the main mining area and areas to the east of it, including Stelae Ridge.[334] Cairn 013 may have served a similar function to cairn 014, but because a stela was associated with it may also have been an outlying ritual cairn with little practical purpose.[335]

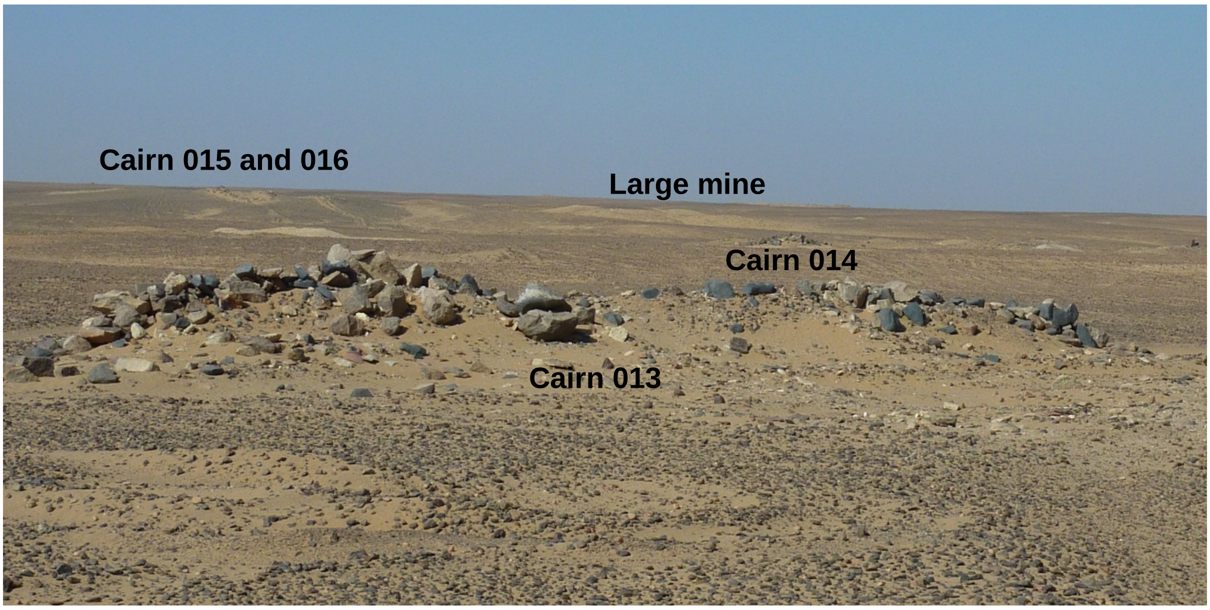


Fig 6.62: Looking west from cairn 013 towards the large mine. Cairn 013 is in the foreground. The ridge with demolished cairns 015 and 016 is in the rear left of the picture. Cairn 014 is the surviving cairn in the mid-ground above its label, and the large mine and main mining area is just visible as the spoil heaps behind it. (Author photograph).

[334] Research on the construction of landmarks along the Abu Ballas trail has shown that intervals between *alamat* were reduced if the environmental conditions made them harder to see, revealing that the Egyptians responded to changing conditions when constructing markers and *alamat* (Riemer 2013, 92–93).

[335] For the stela of Amenemhat II found by the Gebel el-Asr Project at cairn 013, see Shaw (2010, 302).

6.5.3. Conclusion

Consideration of the visibility from the various alternative ridges and surviving cairns revealed that Stelae Ridge was undoubtedly more visible to the landscape and had better views of it than any of the alternatives tested here. This suggests that Stelae Ridge was deliberately chosen because of these properties, reinforcing the conclusion that the earliest structures on it functioned as landmarks and the site was chosen because of its suitability for this purpose.

The visibility analysis of alternative locations also suggests that Stelae Ridge was a marginally more preferable location in terms of its visual relationship with the mining area. The cairns upon it were more visible, while the courts had equivalent or more limited views of the mining area than those on alternative ridges. The differences are not substantial and it is therefore likely that Stelae Ridge's much better visibility within the landscape, perhaps particularly from the areas to the south, was the primarily factor in the location of the cairn-courts. Nonetheless with views of the mining area that were equivalent or more limited than the alternative ridges, with the addition of the cairns to the west of the courts, it was still possible to create cairn-courts at Stelae Ridge that balanced the need for visible cairns and secluded courts.

The visibility analysis of the alternative locations has also revealed several aspects of the visibility of the partially surviving cairns 013, 014, 015 and 016. None of these were particularly visible from the landscape, and would not have made particularly effective landmarks for those approaching the area from afar. However, detailed review suggests that both cairn 015 and cairn 016 were intended to be visible from most of the large mine and the rest of the main mining area, particularly areas that were not inter-visible with Stelae Ridge and the alternative ridges. Similarly, cairn 013 and 014 were visible from the eastern end of the large mine and could have provided effective landmarks for those approaching the main mining area from the east, including from Stelae Ridge. Although the distance is not very far, the mining area is not particularly prominent and would have been more difficult to locate when conditions were poor.

The visibility analysis of cairns 013 and 015–016 does not take into account the location of any courts, since no such structures survived. Cairn 014 is unlikely to have had a court, since it survived largely intact and there is no evidence of either a court or a flat face which could indicate the presence of one. A stela was found near cairn 013, so it is quite likely to have had a court. Given Engelbach's (1933, 69) description, it is entirely possible that some or all of the other cairns were associated with courts containing stelae and other artefacts. Based on the layout at Stelae Ridge, it may be suggested that any courts associated with cairns 015 and 016 would have been either to the west or to the south, depending on whether orientation to the west was more important or it was more important to screen the mines from view of the courts.

If present, courts would imply a dual purpose for the cairns with them, but they do not preclude an interpretation of the cairns as landmarks. Given the juxtaposition of the round cairn with cairn-courts on Stelae Ridge and the apparent interest in good visibility by the constructors of the earlier cairn-courts on Stelae Ridge south, the builders appeared to be quite comfortable with a structure or location serving multiple purposes.

6.6. Conclusion

Interpretation of the results of the systematic visibility analysis of Stelae Ridge from Chapter 5, together with visibility analysis of other locations in the vicinity, in the context of the archaeological evidence has resulted in a number of interesting conclusions. It has shown that the better visibility associated with Stelae Ridge south includes inter-visibility with other archaeological locations around the Gebel el-Asr gneiss quarries and known tracks to the south. Careful consideration of the results of the visibility analysis has also suggested possible new routes across the Gebel el-Asr landscape, which made use of intermediate landmarks for navigation. No evidence was found to indicate a relationship between the later Darb el-Arba'in and Stelae Ridge, although this does not entirely preclude the use of a predecessor of this road during the Middle Kingdom.

In the analysis of the relationship between visibility and the chronological development of the ridge, better visibility was associated with the earlier structures. Later structures exhibited more varied visibility, probably because by the time they were constructed the earlier structures fulfilled the need for landmarks and prime positions were limited. This conclusion was supported by the visibility analysis of possible alternative locations around the main mining area, which revealed that Stelae Ridge had visibility of and was visible from a much larger area than any of the alternative ridges or cairns.

Detailed review of the visibility of the Stelae Ridge cairn-courts with respect to the mining area to their west and comparison with the visibility analysis of alternative ridges and cairns, suggested that there was some tension between the desire for visible cairns and more secluded courts. In this, the practical origins of the Stelae Ridge structures as landmarks were held in tension with the ritual use of the cairn-courts.

The partially surviving cairns 013–016, which were not on Stelae Ridge, had much more limited visibilities. Based on their inter-visibility with the main mining area it is likely that cairns 015 and 016 were intended to function as landmarks for individuals within the Stelae Ridge area or a moderate distance away, although this may not have been their only function. Engelbach (1939, 387) records that he found a stela of Henenu, dating to the reign of Senusret I, at a cairn X near the workings that have since been identified as the large mine in the main mining area. If this is correct, either cairn 015 or 016 should probably be identified as Engelbach's cairn X, and at least one of these cairns then clearly had a social or ritual function in addition to any role as a landmark. Cairn 013 is the only other cairn not on Stelae Ridge which is associated with any artefacts and its location may not therefore be directly related to visibility, as it clearly had a similar role to the Stelae Ridge cairn-courts. However, it is likely that cairn 013 would have provided a useful marker, even if that had not been its primary purpose. Cairn 014 probably served as a landmark for the eastern end of the large mine, which is not particularly visible from a distance.

7. Conclusion

7.1. Overview

The research presented in Chapters 3–6 was undertaken primarily in order to develop and assess new approaches to the investigation and interpretation of cairns, enclosures, stone alignments and other small, 'non-formal' structures located across the Egyptian deserts at mining or quarrying sites and elsewhere in the desert landscape. The case study of the eight Stelae Ridge cairn-courts shows that it is possible to improve understanding of such features using GIS visibility analysis of them. The results of the systematic visibility analysis presented in Chapter 5, contextualised in Chapter 6 with archaeological and epigraphic evidence and the experience of visibility at the site, revealed new information about the practical aspects of the cairn-courts' location, their relationship with the archaeological and topographic landscape and the interaction between their ritual and practical aspects. This method is therefore a viable approach for investigating small, non-formal desert structures at mines and quarries and elsewhere, particularly where there is little or no archaeological, epigraphic or artefactual evidence, and the structures defy traditional research methods.

However, this approach was only successful because the GIS visibility analysis was treated as a data collection tool, rather than an end in itself.[336] The visibility analysis did not just determine what was visible from the Stelae Ridge structures, but compared and analysed their viewsheds to answer archaeologically meaningful questions about the chronological development and function of the cairn-courts and their relationship with the surrounding landscape of the Gebel el-Asr gneiss quarries. Preliminary research presented in Chapters 3–4 was necessary to contextualise the results, and subsequent interrogation of those results in Chapter 6 involved integrating them with that preliminary research and undertaking additional visibility analysis.

This type of multi-disciplinary research, using GIS visibility analysis combined with archaeological and epigraphic evidence in an appropriate theoretical framework, is currently virtually unknown in Egyptian archaeology and in research into Egyptian ritual and religion. While a number of studies have made use of both archaeological and documentary evidence,[337] most research into Egyptian ritual and religion has been limited to one or the

[336] GIS visibility analysis is often criticised for being more interested in new software and techniques, than answering meaningful archaeological questions (Brück 2005, 54; Chadwick 2004, 21; Chapman and Geary 2000; Gillings 2009, Thomas 2004, 198–201).
[337] See for example Ignacio *et al.* (2012); Kemp (1995; 2006); Meskell (1999; 2002); O'Connor (1985; 1992); Richards (2005); Trigger *et al.* (1983).

other.[338] As discussed in Chapter 1 section 1.3.1, previous investigations of visibility in Egyptian contexts have largely focussed upon relationships between specific landscape features and iconography. Almost none have employed GIS software, phenomenology or other related methodologies. As a result, they are generally quite superficial and often lack sufficient evidence to support their conclusions. GIS analysis, including visibility analysis, combined with contextual evidence, offers many currently untapped opportunities for future research, including specific research at Stelae Ridge, at non-formal structures at other sites and more widely in Egyptian archaeology.

7.2. Results of the Stelae Ridge case study

Following a review of existing archaeological evidence, a new archaeological survey of the site and GIS research into the location and layout of the structures at Stelae Ridge, the systematic visibility analysis provided a body of data concerning the different visibilities of the Stelae Ridge cairn-courts, individually and in groups. This data, presented in Chapter 5, revealed significant differences in visibility between the two ridges, between the visibility of individual structures and others on the same ridge, and between the structures as constructed and the unmodified ridges.

Interpretation of the data from the systematic visibility analysis in the context of the archaeological and epigraphic evidence from the site, the Egyptian historical and cultural context, and the author's personal experience of visibility, revealed new interpretations of the structures. The number of early structures on the more visible Stelae Ridge south, suggested that visibility was an important factor in their location, beginning with cairn III, which can now be interpreted as an early marker cairn. Later structures moved to peripheral locations on Stelae Ridge south, or to Stelae Ridge north, where views of the landscape and

[338] Studies on Egyptian religion based on documentary and epigraphic evidence are too numerous to list in full, but include Assmann (1970; 1995; 2001); Aufrère (1991; 2001); Baines (1984; 1987; 1991); Eichler (1994); Hikade (2006); Hornung (1982; 1992); Lesko (1991); Lloyd (2013); Ritner (1992); Rundle-Clark (1959); Sadek (1988); Simpson (1974);); Wilkinson (1994). Studies based upon archaeological evidence are more limited. Notable examples include Bussmann (2011); Ikram (1989); Kemp (2006, chapter 3); O'Connor (1985; 1992); Pinch (1993); Snape and Wilson (2007); Spence (2007); Stevens (2003; 2006); Weiss (2009). The separation between archaeology and text is exemplified in many excavation reports where the documentary or epigraphic sources are published separately from archaeological remains and there is very little integration of the different sources of evidence. Examples include sites such as Ayn Soukhna (Abd el-Raziq *et al.* 2002; 2011) and Gebel el-Zeit (Castel and Soukiassian 1985a; 1989; Régen and Soukiassian 2008). At Wadi el-Hudi (Fakhry 1952; Sadek 1980) and various sites in Sinai (Petrie 1906; Černy *et al.* 1955) publication of the texts and archaeology were undertaken at different times by different people. Valbelle and Bonnet's (1996) publication of the temple of Hathor at Serabit el-Khadim is a notable exception to this. Other cases where archaeological and documentary evidence is integrated into a single study include Harrington (2013); Pinch (1994); Quirke (2001); Richards (2005); Teeter (2011).

visibility of the cairns were reduced, suggesting that visibility was no longer a primary concern, perhaps because earlier cairns fulfilled the requirement for landmarks.

The importance of visibility for the earlier cairns III, IV and V on Stelae Ridge south was associated with the very good visibility this ridge afforded for viewing and being seen from the landscape to the south, where the archaeological sites of the Gebel el-Asr gneiss quarries, and the route between the site and the Nile were located. Comparison of the viewsheds with posited routes across the landscape, revealed something of the interconnections present in the landscape and experienced by those who occupied it.

Comparison of the viewsheds for the Stelae Ridge cairn-courts and the location of the mines to the north and west of the site revealed that, even before the cairns were constructed, inter-visibility between the courts and the main mining area was limited. The construction of the cairns increased the visual separation of the courts from the working area, perhaps to create a distinction between the secular space of the mining area and the ritual activities taking place in the courts. Other factors may also have influenced the location of the cairns in relation to the courts, but these are not amenable to investigation by visibility analysis.

Given that the structures were located on a ridge and the cairns were highly visible from the mining area, there was perhaps some tension between the need for prominent cairns and secluded courts. It is not known whether there was an underlying ritual justification requiring that the cairns should be visible, even while the courts were more secluded, or whether their prominence was a result of their original practical function as landmarks. The continuing use of Stelae Ridge for cairn-courts even after the earliest structures fulfilled the need for landmarks, suggests that, even after practical visibility ceased to be an issue in the construction of new cairn-courts, a prominent location was still sought. This may have been because some degree of prominence had now become a significant element of ‘correct’ cairn-court construction. Other demolished cairns were found on ridges during the 2012 survey. Even though cairn 013 (which is associated with a stela of Amenemhat II and may have had a ritual court) was located off Stele Ridge itself, on a lower slope to the west, visibility analysis suggests that it would have been quite visible to its immediate surroundings. Tension between superficial visibility and hidden inner rituals is consistent with many other Egyptian religious and funerary constructs from majestic pyramids with hidden inner chambers to externally impressive temples with restricted inner sanctuaries.

Comparison of the systematic visibility analysis of Stelae Ridge with new visibility analysis of other ridges around the Stelae Ridge mines suggested that the eight cairns were constructed at Stelae Ridge because it offered better views and was more visible, particularly from the south.

7.2.1. Practical and ritual interpretations of the Stelae Ridge cairn-courts

Although many of the conclusions of the visibility analysis related to practical aspects of the cairn-courts, these do not exclude the ritual interpretations advanced on the basis of the artefacts and inscriptions at the site.[339] Instead, the practical aspects of the cairn-courts complement and enhance existing ritual interpretations of these structures and provide insights into how practical function and ritual significance operated together.

Based on its nature and visibility, cairn III has been interpreted as a structure that was initially practical, sited to take advantage of the good views and highly visible location of Stelae Ridge. This originally practical cairn then attracted other structures, which were either solely or primarily of a ritual nature, based on the presence of the courts and the inscribed artefacts within them. It is even possible that cairn III developed some ritual or symbolic associations either prior to or around the same time that these more obvious ritual structures were constructed. Whether the earliest of the ritual cairn-courts, IV and V, were also intended to function as landmarks or whether this was a happy coincidence of their proximity to cairn III on the highest part of the ridge, is irrelevant. It is the juxtaposition of clearly ritual structures with at least one that is practical in origin that suggests ritualisation of the cairn-building process and perhaps the actual ridge as well.[340] Unlike the work of Bradley (2005) on prehistoric Europe, there has been almost no investigation of the ritualisation of practical or mundane tasks in Egyptian archaeology and this is an aspect of Egyptian civilisation that might well repay further study.[341]

The process of ritualisation might ultimately have led to a separation between the original function of cairns as landmarks and their later development into ritual structures. By the time the latest cairn-courts were constructed on Stelae Ridge in the reign of Amenemhat III, the visibility of these structures was apparently relatively unimportant since they were located at the periphery of Stelae Ridge south and on the much less visible Stelae Ridge north. One

[339] For the ritual interpretations of the structures see the summary in Chapter 3 section 3.1; Darnell and Manassa (2013) and Pethen (2006).
[340] For ritualisation see Verhoeven (2011, 123); Humphrey and Laidlaw (1994); and Bell (1993).
[341] Studies of 'ritual' in the Egyptian context tend to consider it as a separate category and investigate it as such (Baines 1991; Harrington 2013; Pinch 1993; Sadek 1988; Spence 2007; Stevens 2011). Meskell (2004, 83) comments that 'every artefact is a performance', but in her (2002; 2004) studies of Egyptian culture from a phenomenological and embodied perspective she focusses upon specifically religious and ritual behaviour rather than the ritualisation of practical or mundane activities. Concentrations of archaeological, epigraphic and petroglyphic remains at other desert loci have been interpreted as evidence of 'place-making' activities intended to socialise desert landscapes (Darnell 2009; Garnett 2013; Riemer and Förster 2013, 39–42), but these interpretations have not considered aspects of ritualisation or the relationship between the practical or mundane aspects of these remains and their ritual or social functions.

might posit a more purely ritual function for these cairns, although the evidence is ambiguous. Most of the cairns dating to the reign of Amenemhat III are less visible, but the existing cairns on Stelae Ridge south might have fulfilled all practical or ritual requirements for visibility, at least towards the south. Ritual visibility need not be the same as practical visibility. The cairns on Stelae Ridge north were highly visible from the mining area. This could have fulfilled the ritual requirement for visibility, it may have had a practical purpose in facilitating movement across the landscape or it could have been a collateral effect of the cairns' builders constructing them at the end of Stelae Ridge closest to their working environment.

The interplay between the ritual and practical aspects of the Stelae Ridge structures is exemplified in the tension between the visibility of the cairns and seclusion of the courts from the mining area. Visibility of the cairns from the landscape, a primary factor in the choice of Stelae Ridge, is associated with the role of the cairns as landmarks. The location of the structures on a ridge, the choice of Stelae Ridge over other less prominent and less visible ridges, and the presence of the earliest structures on the much more visible Stelae Ridge south, all confirm this. The effort made to seclude the courts from the work of the mining area is likely to have a ritual reason. The tension between visibility and seclusion is then a tension between the practical and ritual elements of the structures. In the case of the later cairn-courts, which were located on the ridge despite not having much of a role as landmarks, this tension may have evolved into a ritualised element of cairn-court construction, that now demanded they incorporate both visible and secluded elements.

7.2.2. Limitations

As an exercise in data collection, the visibility analysis was subject to certain limitations derived from the resources used and the parameters chosen. Some of these parameters could be tested to assess their effect upon the visibility analysis. Comparison of ArcGIS 10.1 viewsheds with viewsheds created by GRASS 7.0 revealed that the differences between the algorithms used by different GIS programmes have an impact upon the size and shape of the resulting viewsheds, even when all other parameters are kept the same.[342] It was not possible to consider the precise nature of the ArcGIS 10.1 viewshed algorithm, but comparison with the author's experience of visibility at the site suggested that the smaller viewsheds created by ArcGIS were generally closer to the real experience of visibility than

[342] For the comparison between the algorithms used by ArcGIS 10.1 and GRASS 7.0 see Chapter 2, section 2.7.1.

the larger viewsheds produced by GRASS.[343] Testing the effect of the azimuths, changes in cairn height and changes in observer location revealed that the impact from these parameters were small or minimal. Although the ranking of the cairns on Stelae Ridge south was particularly sensitive to changes, the tests of the parameters used in visibility analysis provided an effective control, which helped to avoid erroneous conclusions derived from the effects of the visibility analysis parameters rather than the visual properties of the Stelae Ridge cairn-courts.

There are other parameters that could not be controlled. These were associated with the damaged nature of the site, which prevented the inclusion of individual cairn heights, full checking of Engelbach's sketch plan and recording of the original topographic form of Stelae Ridge. The SRTM DEM was also associated with a number of limitations, including its low resolution and the inclusion of modern alterations to the landscape.

Future research might be able to improve upon some of these limitations. Further experimentation with different GIS programmes and comparison with real visibility might confirm which programme has the algorithm which produces the most reliable viewsheds. The need for azimuths could be obviated by including the massing of the cairns in the visibility analysis, either by obtaining a very high resolution satellite DEM or undertaking a full topographic survey of the site. The surviving cairns would then be included in the DEM and the destroyed ones could be reconstructed, albeit imperfectly, using data from the surviving cairns. A high resolution DEM would also resolve the problem with the coarse resolution of the SRTM, but could not address the inclusion of modern alterations to the landscape unless it was derived from satellite imagery recorded before those alterations took place. CORONA photographs offer one possible source of such imagery, but generating DEM from them is a specialist task, requiring dedicated software. CORONA imagery is also associated with its own limitations, discussed in Chapter 2, section 2.2.1.

7.3. Future work

The success of this research in arriving at new and more detailed interpretations of the Stelae Ridge cairn-courts has implications for future work at Stelae Ridge and elsewhere. At Stelae Ridge it suggests new lines of investigation into the wider landscape and the relationship between the different loci of ancient activity in and around the Gebel el-Asr quarries. More generally both GIS and visibility analysis have applications at sites across Egypt, testing past assertions about visibility and undertaking new investigations of sacred

---

[343] For the author's experience of visibility at the site see Chapter 3, section 3.7.3.

and secular landscapes. It offers the opportunity to investigate cairns and other non-formal structures at mines and quarries and more widely, and holds out the possibility of comparing the evidence from Stelae Ridge with other similar sites.

7.3.1. Further study of Stelae Ridge

GIS visibility analysis could be employed in a variety of forms to enhance and develop the research presented here. Parameters such as the height or the position of the human observer could be varied, in order to investigate different experiences of visibility. By creating a series of viewsheds approaching and within the courts, it would be possible to analyse how visibility changed as one approached the cairn-courts, how the cairns constrained visibility and focussed attention upon the court and how the view of the landscape changed as the individual moved away from the court. The methods described in Chapter 2, section 2.7.5 for modelling the changes in visibility as distance from the viewer increases, could be used to demonstrate how perspective changes.

In conjunction with additional *in situ* archaeological survey and, perhaps, phenomenological records of experience, visibility analysis could also be used to assess visibility within the wider landscape around Stelae Ridge. There are a number of known archaeological features in the area, as well as potentially unknown new cairns or similar structures, which might repay visibility analysis. The Old Kingdom and Middle Kingdom archaeological sites within the Gebel el-Asr gneiss quarries also offer opportunities for visibility analysis. The Gebel el-Asr Project recorded a number of archaeological sites, cairns and landmarks along the route between Quartz Ridge and the Nile, and observed that visibility was a key component of the identification of these features. Systematic viewshed analysis along this route, and others posited on the basis of this research, might reveal new archaeological sites and provide insight into how people moved across the Gebel el-Asr landscape, how routes were marked and where they were located.

7.3.2. General implications for Egyptian sites

Egyptian archaeology has long been interested in visibility, as is attested by some relatively early publications referred to in Chapter 1, section 1.3.1. Some of these were concerned with simplistic associations between topography and hieroglyphic symbols. But more complex questions of inter-visibility involving Old Kingdom pyramids and settlement in the Nile valley (Jeffreys 1998; 2010; Love 2004), the layout of cemeteries and settlements (Richards 1999; 2005) and New Kingdom tombs and temples at Luxor (Jimenez Higueras 2012) require explicit methodology and, preferably, systematic analysis to provide meaningful conclusions and permit comparisons between sites.

Egyptology has previously been characterised by a separation between archaeology and documentary evidence and a general lack of interest in archaeological theory.[344] This is probably responsible for the very limited use of GIS and the almost complete absence of visibility analysis in the discipline generally, as well as in research into Egyptian religion and ritual. As Egyptology develops a deeper relationship with archaeological theory and methods across the rest of the world, Egyptian archaeologists will increasingly seek to answer new questions and investigate sites and features that are not easily amenable to traditional forms of analysis and interpretation involving artefacts, inscriptions and archaeological context. The systematic visibility analysis presented here can provide both the analytical tool and the interpretive framework, for the investigation of old and new sites and landscapes.

7.4. Visibility analysis at other sites

The problems associated with interpreting cairns, enclosures, upright stones and stone alignments have already been discussed in Chapter 1, section 1.2. The successful interpretation of the Stelae Ridge cairn-courts suggests that this method could be employed at other sites to investigate similar structures. To gain some insight into what this method might reveal if applied to other sites, a rapid visibility analysis was undertaken of two other groups of non-formal archaeological features at two different archaeological sites. These two groups comprised the archaeological features along the approach to the temple of Hathor at Serabit el-Khadim in the Sinai (Petrie 1906, 63–67; Valbelle and Bonnet 1996, 70–73) and the cairns and shrines at Hatnub (Shaw 2010). These two groups have been chosen because recent plans of them have been published by their excavators and, once georeferenced, these plans give an indication of suitable observer and target locations for visibility analysis. They also have slightly different characteristics and represent different types of the non-formal structures that are found at desert sites.

The archaeological features at Serabit el-Khadim are quite comparable to those at Stelae Ridge. They date from the 12th Dynasty of the Middle Kingdom, from the reign of Senusret I to Amenemhat III, and comprise inscribed stone stelae and circular stone enclosures, sometimes found together and sometimes separately. However, unlike the cairn-courts at Stelae Ridge, these features are spread across *c.* 420m along the approach to a small temple built against a low hill, into which a sanctuary to Hathor was constructed. The Serabit

[344] Richards (2005, 13–19) discusses the problems associated with the separation between archaeology and documentary evidence in Egyptology. Wendrich (2010a; 2010b) summarises the very limited historical interaction between Egyptian archaeology and archaeological theory and emphasises how engagement with theory provides opportunities for more nuanced and interdisciplinary interpretations.

el-Khadim features are therefore subsidiary or secondary to a more typical Egyptian temple and, partly because of this, are also associated with a much larger body of textual material (Černy *et al.* 1955).

The archaeological features at Hatnub are less comparable to the material from Stelae Ridge and Serabit el-Khadim, although they are of the same general type. They comprise a number of cairns, alignments of orthostats and structures interpreted as 'shrines' by Shaw (2010, 101–105), widely distributed across an area that was also used for habitation and processing of travertine. Although there are inscriptions in the quarries,[345] there are no surviving stelae, artefacts or inscriptions associated with the individual cairns, orthostats and shrines. It is therefore difficult to suggest a specific function for them, although a general 'ritual' purpose is suspected. If the cairns, orthostats and shrines are of the same Old Kingdom and First Intermediate Period date as the inscriptions in Quarry P and the Old Kingdom structures in the settlement around them,[346] they would be earlier than both the material from Serabit el-Khadim and Stelae Ridge. However, in the absence of archaeological or textual dating evidence for most of the Hatnub ritual features, their date can also be questioned. The features at Hatnub thus extend the research beyond non-formal structures associated with epigraphic evidence and beyond the Middle Kingdom focus of Stelae Ridge and Serabit el-Khadim.

7.4.1. Method

To ensure the data from the three different sites could be compared, as far as possible the method for the rapid visibility analysis of Serabit el-Khadim and Hatnub followed that employed by the Stelae Ridge visibility analysis and presented in Chapter 2. The location of the observer points was naturally different for each site as these were determined by the position of the surveyed archaeological features at Serabit el-Khadim and Hatnub.

The published plans of the archaeological features at Serabit el-Khadim and Hatnub were georeferenced using the same process. Ground control points were identified from Google

---

[345] The inscriptions in the quarries were briefly mentioned by Petrie (1894, 3–4), recorded by Blackden and Fraser (1892; Fraser 1984) and finally published extensively by Anthes (1928) using the records made by Georg Möller in 1908.

[346] The majority of the inscriptions recorded in Quarry P date from the Old Kingdom to First Intermediate Period (Anthes 1928; Shaw 2010, 135–162). Structures across the settlement around Quarry P consistently produced Old Kingdom pottery. New Kingdom pottery was limited to occasional sherds across most of the settlement and even where the greatest concentration of New Kingdom pottery was found, around structures W1–51 and NW1–5, the presence of Old Kingdom pottery revealed that some of these structures were re-used rather than newly built in the New Kingdom (Shaw 2010, 41–73).

Earth through the ‘open layers’ plugin of QGIS,[347] which allows Google Earth satellite imagery to be viewed in QGIS. The coordinates of the ground control points were extracted from QGIS and used to georeferenced the plans in ArcGIS 10.1. The resulting RMSEs of the rectified plans were generally quite high, because of the problems encountered georeferencing the plans using the Google Earth imagery. It was difficult to identify suitable ground control points, and ensure they were located with precision using Google Earth satellite imagery, which has lower resolution than the plans, is projected on the unstable Google Mercator projection and exhibits geolocational imprecision. Consequently there are likely to be errors in the location of the ground control points and therefore in the rectification of the plans based upon them. These same problems may also result in inaccuracies which have not been quantified within the RMSE. Unfortunately, without additional evidence from other sources or site survey, no better rectification can be attempted. However, because the SRTM used in this visibility analysis only has a resolution of 87m, slight inaccuracies in the positioning of the archaeological features will not affect their relationship with the DEM cells. Therefore, although a more accurate position for the archaeological features would be preferred, the rectifications of the plans are sufficient for this rapid visibility analysis, to demonstrate the possibilities of extending this type of research to other sites.

To ensure the results of the visibility analysis could be compared with those from Stelae Ridge, the computer programme, type of visibility analysis, type of DEM, observer height and target height were all kept the same. Both projective and reflective visibility analysis was undertaken.[348] During the visibility analysis of Stelae Ridge comparison of the shapes and sizes of the individual inclusive viewsheds of each observer point revealed the most about the site. Therefore the rapid visibility analysis of the structures at Serabit el-Khadim and Hatnub made use of observer points analysis.[349] Individual inclusive viewsheds for each observer point were then extracted and quantified using the methods described in Chapter 2, section 2.4.3 and 2.4.4. The overall projective and reflective viewsheds for each archaeological feature are shown in the figures and quantified in the tables for the area of the viewshed within the maximum visual range of 15km radius from the sites.

As in the visibility analysis of Stelae Ridge, ground level at the observer points was determined by the SRTM, the observer height was set to 1.6m and the target height was set to 0m. Since only some of the archaeological features would have had restricted visibility

[347] https://plugins.qgis.org/plugins/openlayers_plugin/, last accessed 18 March 2015.
[348] For how projective and reflective viewsheds are created, and how the visibility analysis is controlled, section Chapter 2, section 2.4.2.
[349] The use of ArcGIS 10.1 observer points analysis in this research is described in Chapter 2, section 2.4.1.

when viewed from certain directions, azimuths were not employed. This ensured simplicity and consistency across the data. For similar reasons the reflective visibility analysis used a target height of 0m to represent the archaeological features when viewed by human observers in the landscape. The results of the visibility analysis of Serabit el-Khadim and Hatnub are therefore directly comparable to the projective visibility analysis of the Stelae Ridge courts undertaken without azimuths, and the reflective visibility of ground level at the Stelae Ridge cairns.[350]

Future research could include the known or suspected heights of the archaeological features at Serabit el-Khadim and Hatnub, and their influence upon visibility, but this is a rapid visibility analysis and is not intended to be exhaustive. Rather it is intended to provide some evidence of what may be learned by comparison of data from different sites Therefore the number of visibility analyses undertaken for each site was restricted and the parameters for all archaeological features at both sites were kept consistent to ensure the data were directly comparable with each other.

7.4.2. Serabit el-Khadim

During his research in Sinai in the early 20th century, Petrie (1906) recorded the archaeological remains around the temple of Hathor at Serabit el-Khadim. These remains included ‘rough rings of stone piled upon the ground (Petrie 1906, 65)’ associated with inscribed stelae (Černy *et al.* 1955) and located along the track across the plateau to the temple. The earliest of these stelae dated to the reign of Senusret I and one well-preserved example had been set up on one side of an enclosure behind an offering table (Petrie 1906, 66), a layout similar to that present at cairn VIII of Stelae Ridge (Darnell and Manassa 2013). A number of these enclosures and the positions of some stelae were surveyed and published by Valbelle and Bonnet (1996, 70; Fig 7.1), although they dispute whether all the stone circles were associated with stelae.[351]

---

[350] For the projective visibility analysis of the Stelae Ridge courts without azimuths see Chapter 5, section 5.2.2, and for the reflective visibility analysis of ground level at the Stelae Ridge cairns see Chapter 5, section 5.4.1.

[351] Valbelle and Bonnet (1996, 70) suggest that only two of the stelae were originally associated with enclosures because Petrie only describes in detail two of the stelae and their enclosures. However, more detailed reading of Petrie’s account reveals that he describes finding ‘a dozen’ stelae on the path to the temple. Having described the stela of Senusret I and his surprise at the non-funereal context of the inscriptions, he then states that ‘these stones are nearly all connected here with rough rings of stones piled upon the ground (Petrie 1906, 65)’. Given the context, the first use of ‘stones’ in this sentence refers back to the dozen stelae, including that of Senusret I, discussed in the previous paragraphs. His description of the contexts of the stela of Senusret I and of Sobekherheb are then presented as examples. Thus it is likely that most, if not all, of the stelae found on the approach to the

Observer points

The plan published by Valbelle and Bonnet (1996, plan 1) was georeferenced using the method described in section 7.4.1 and the resulting rectified plan (Fig 7.1) had an RMSE of 8.57m.

Following rectification of Valbelle and Bonnet's plan, 13 observer points were identified for visibility analysis. These locations are shown in Fig 7.2 and listed in Table 7.1.

Table 7.1: Observer points for visibility analysis at Serabit el-Khadim. Dates follow those of Valbelle and Bonnet (1996, 70–73).

Observer point	Nature	Date
SK1	Stela 66	Senusret I
SK2	Stela 82	Senusret III
SK3	Stela 403/404	Senusret I (403) and Amenemhat II (404)
SK4	Stela 73/ Stela of Sobekherheb	Amenemhat II (73) and Amenemhat III
SK5	Stela 133	Undated (probably late Middle Kingdom)
SK6	Stela 138	Undated (probably late Middle Kingdom)
SK7	Stela 147	Undated (probably late Middle Kingdom)
SK8	Stela 74	Amenemhat II
SK9	Circular enclosure to west	NA
SK10	Circular enclosure by path division	NA
SK11	Stela 146	Senusret III (probably)
SK12	Shrine of Kings	Amenemhat II
SK13	Hathor hill	Senusret I

The observer points were chosen pragmatically to include the locations of stelae, circular enclosures and the two key components of the Hathor temple; the Hathor hill, where the rock-cut sanctuary was constructed (SK13); and the Shrine of Kings (SK12).[352] SK6–SK8 and SK11 represent the positions of stelae, while SK9 and SK10 are located within circular enclosures shown without stelae by Valbelle and Bonnet (1996, plan 1).

---

temple were originally associated with stone enclosures and that in most cases this connection was still visible and remarked upon in Petrie's time.

[352] For the origin and location of these elements of the temple see Valbelle and Bonnet (1996).

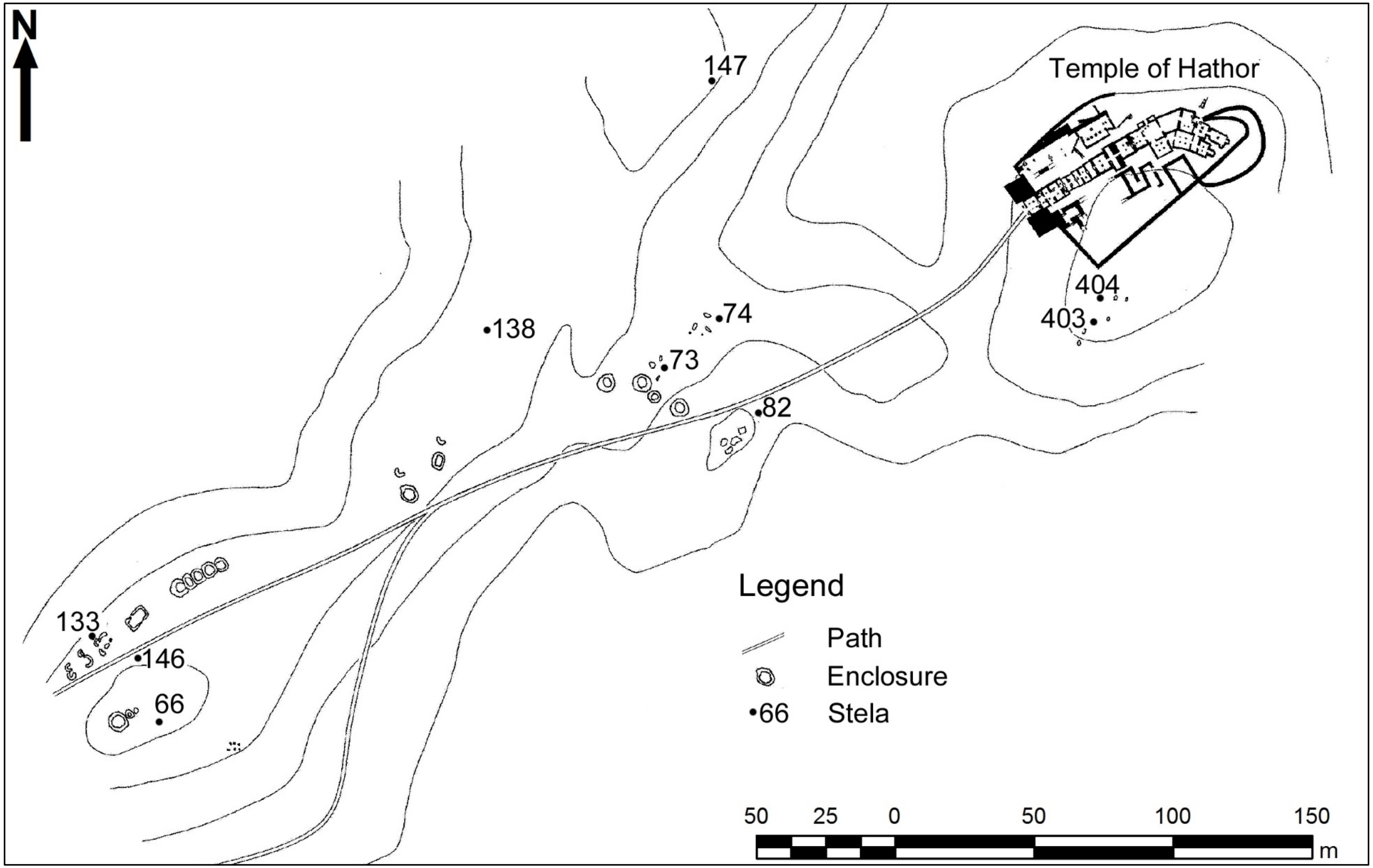


Fig 7.1: Plan of the archaeological features along the approach to the temple of Hathor at Serabit el-Khadim (Adapted and georeferenced from Valbelle and Bonnet 1996, plan 1).

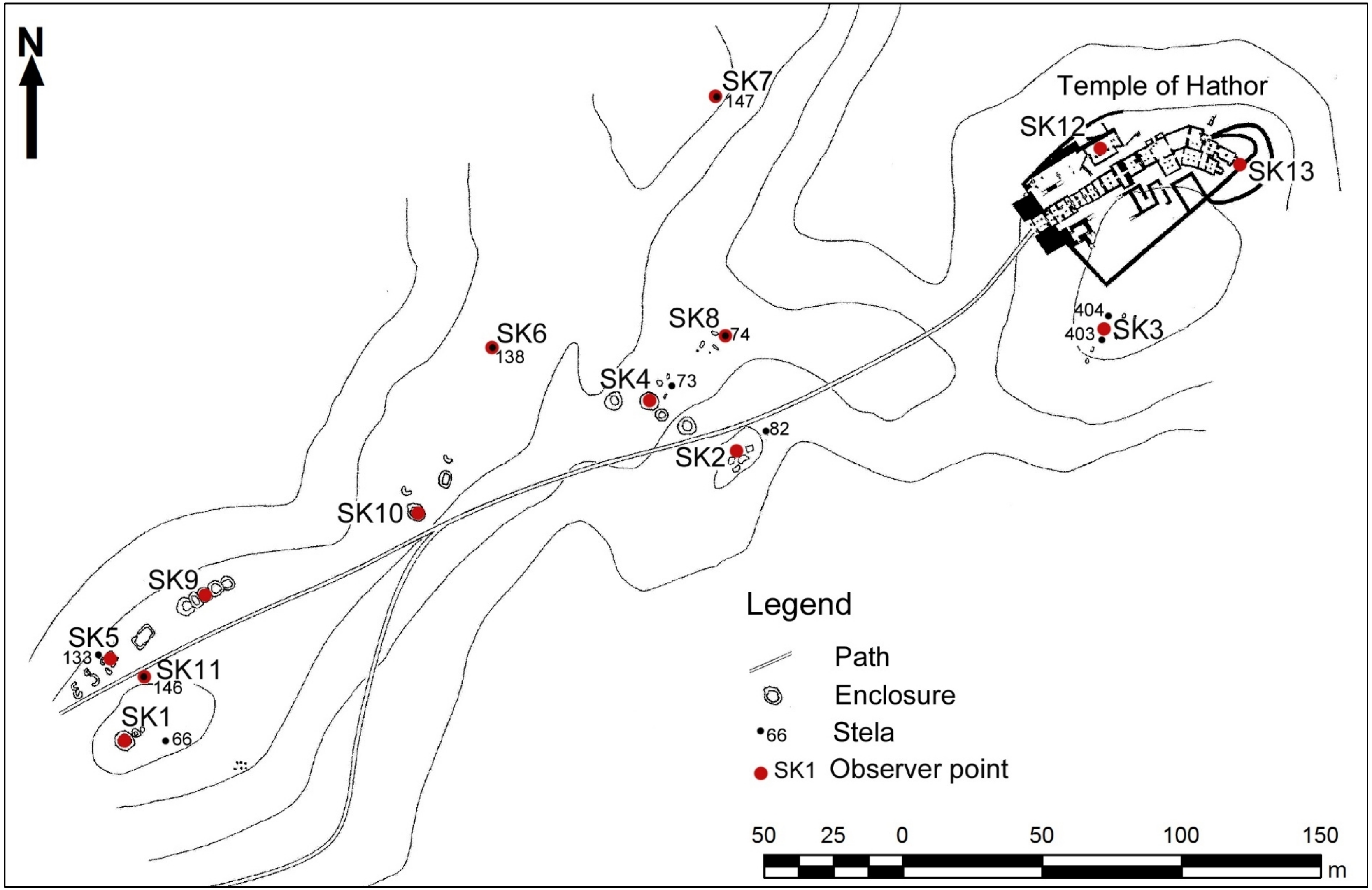


Fig 7.2: Location of 13 observer points, around the temple of Hathor at Serabit el-Khadim, used in the visibility analysis (Adapted and georeferenced from Valbelle and Bonnet 1996, plan 1).

At SK1 and SK2 where archaeological evidence presented in Petrie (1906, 65–67) or Valbelle and Bonnet (1996, 70–73) indicated that stelae had originally been in circular enclosures or on a hill, the observer points were located within the appropriate circle or on the hill and not the stela's later position, recorded by Valbelle and Bonnet's survey (Fig 7.1 and Fig 7.2).

SK4 and SK5 were similarly located in the circular enclosures adjacent to stelae 73 and 133 because the stelae were most likely originally located within these structures and, given the resolution of the SRTM, a slight change in location is unlikely to make any difference to the visibility analysis. For the same reason, one observer point was felt sufficient to represent the two stelae 403 and 404, because of their close proximity to each other.

Apart from stela 66, represented in the visibility analysis by SK1, Petrie (1906, 65–66) specifically mentions a stela of Sobekherheb set up at the edge of a stone enclosure with an offering table below it. The stela and offering table (107) date to the reign of Amenemhat III and are now in the British Museum (EA694 and EA695). The original location of these artefacts are not recorded on Valbelle and Bonnet's plan as they were no longer *in situ* when the survey was undertaken. However, Petrie (1906, Fig 78) published a photograph of the stela and enclosure, captioned 'Enclosure and stela of Sebek-her-heb, looking west'. This photograph clearly shows the enclosure containing the stela was located north of the path to the temple and east of the junction of the paths. Petrie specifies in the text that the low hill with the enclosure and stela 66 of Senusret I are visible in the distance, to the right to the twin peaks of Gebel Umm Riglayn. Since the hill with stela 82 is not visible in the photograph, the enclosure and stela of Sobekherheb must have been to the west of that hill. Taken together this evidence places the stela of Sobekherheb in one of the enclosures around SK4.

In the absence of any opportunity to visit the site and assess visibility on the ground, this conclusion was confirmed by the identification of the distinctive horizon from Petrie's photograph in the Google Earth ground-level view looking south-west from the approximate position of SK4 (Fig 7.3). Since it is impossible to be more precise about the location of the enclosure of Sobekherheb and the SRTM resolution is only 87m anyway, SK4 is considered to represent the location of both stela 73 and the enclosure of Sobekherheb adequately.

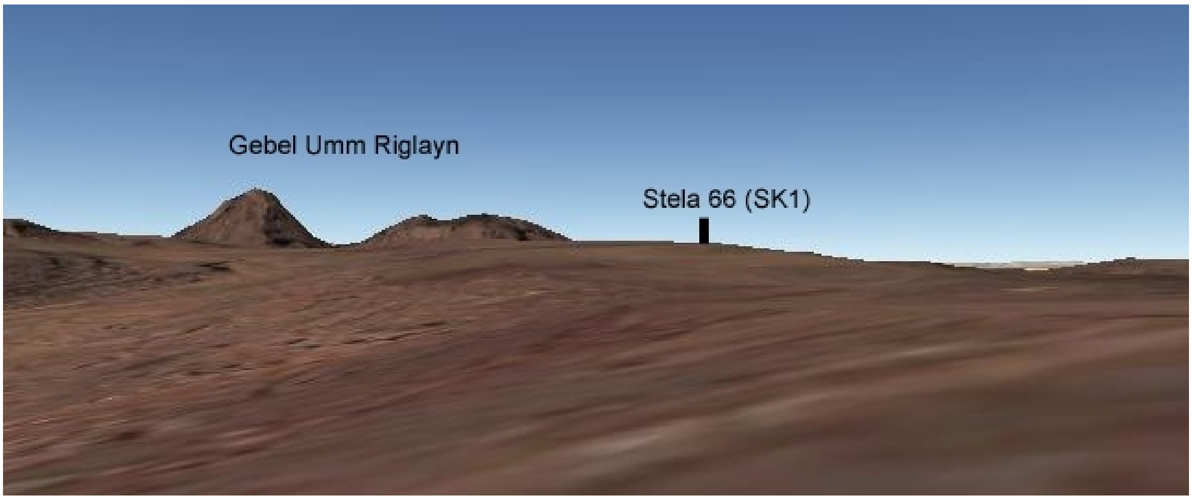


Fig 7.3: Google Earth ground view image showing the view from approximately the same position as Petrie's (1906, Fig 78) photograph, looking westwards beyond the enclosure and stela of Sobekherheb. The topography is based on the SRTM digital elevation model and the overlying satellite imagery is from 2013. Terrain elevation at the viewpoint is 761m.

Results

Following the projective and reflective observer points analysis of SK1–SK13 the individual projective and reflective viewsheds for each SK point are presented in Fig 7.4 – Fig 7.16. Table 7.2 provides details of the size of the viewsheds in number of raster cells, area in km^2 and ranks the viewsheds from 1 to 13, where 1 is the largest and 13 the smallest.

Fig 7.4 – Fig 7.16 show that the 13 viewsheds are relatively restricted in area, with only an area to the north of the site consistently inter-visible with multiple observer points. This area is from *c.* 315° to 45° or from north-west to north-east and the key topographic feature visible to the observer points is the large Wadi Garf, which separates the plateaux and wadis of the area around Serabit el-Khadim from the escarpment of the Tih plateau to the north (Fig 7.17). A small area around the temple and the archaeological features is also inter-visible with the observer points and SK2 (Fig 7.5), SK4 (Fig 7.7), SK6 (Fig 7.9), SK8 (Fig 7.11) and SK10 (Fig 7.13) are inter-visible with some isolated peaks to the south, including the Gebel Umm Riglayn (Fig 7.3 and Fig 7.17).

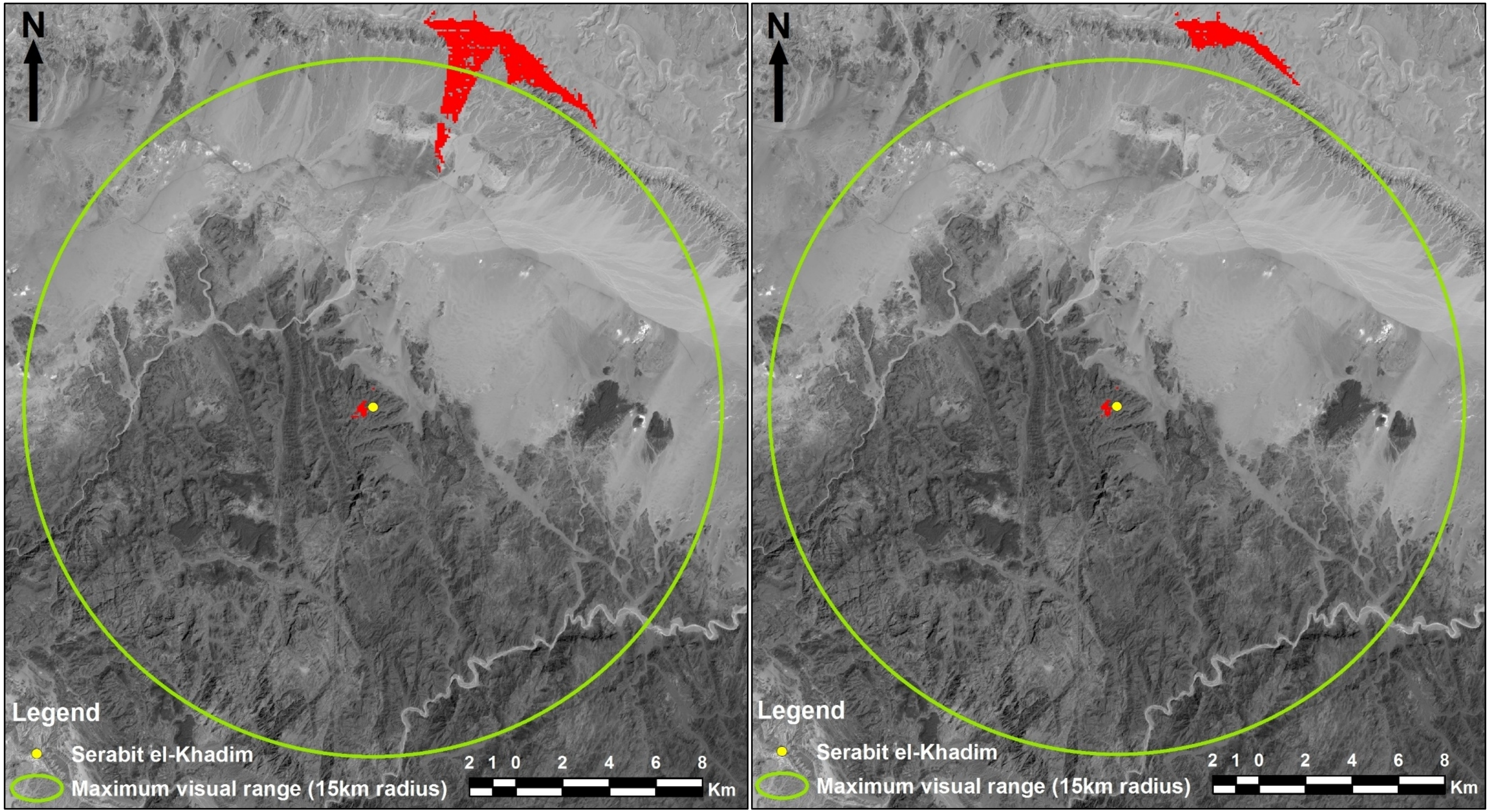


Fig 7.4: Viewsheds for SK1 a) Projective viewshed showing what was visible to SK1 (left) and b) Reflective viewshed showing where SK1 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

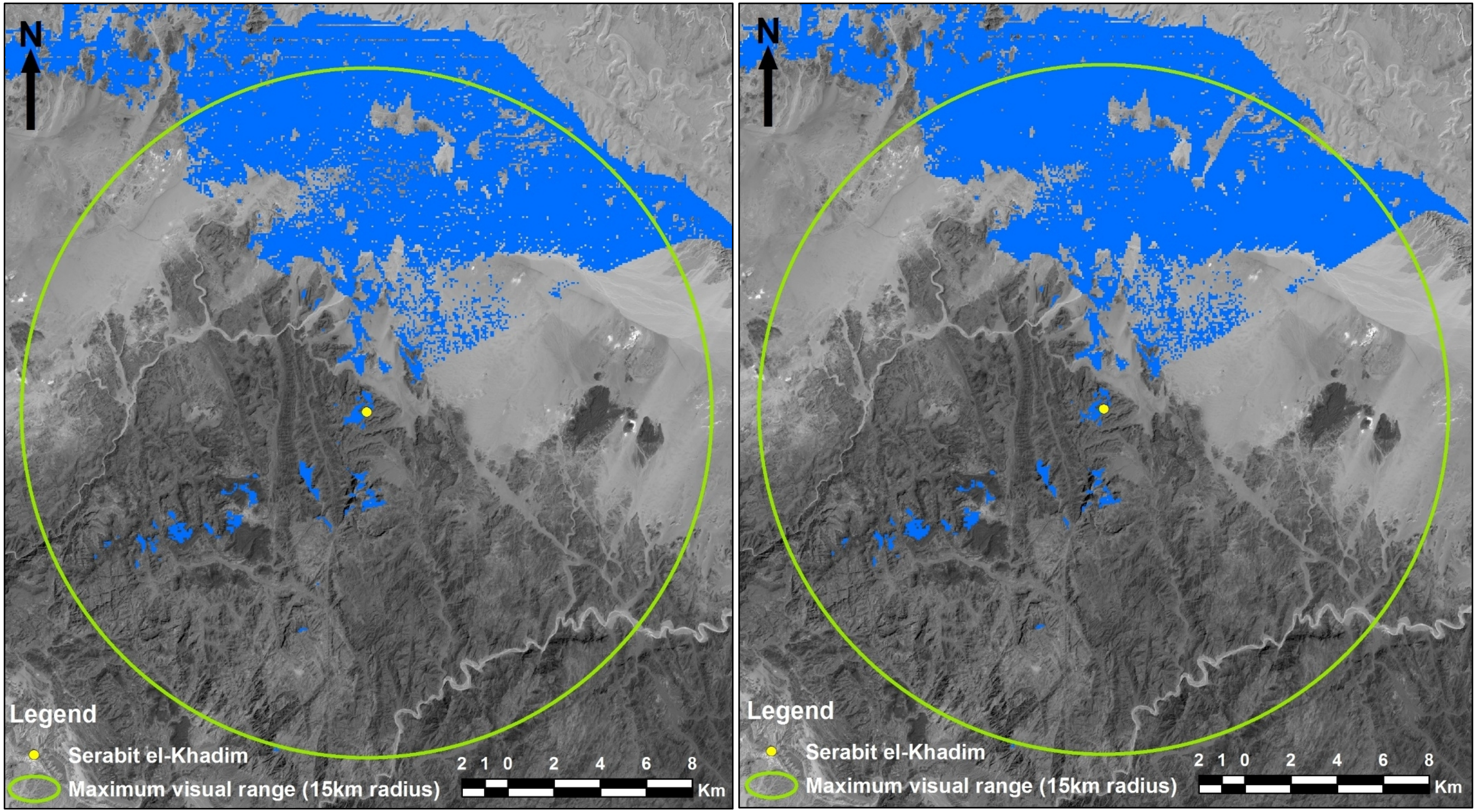


Fig 7.5: Viewsheds for SK2 a) Projective viewshed showing what was visible to SK2 (left) and b) Reflective viewshed showing where SK2 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

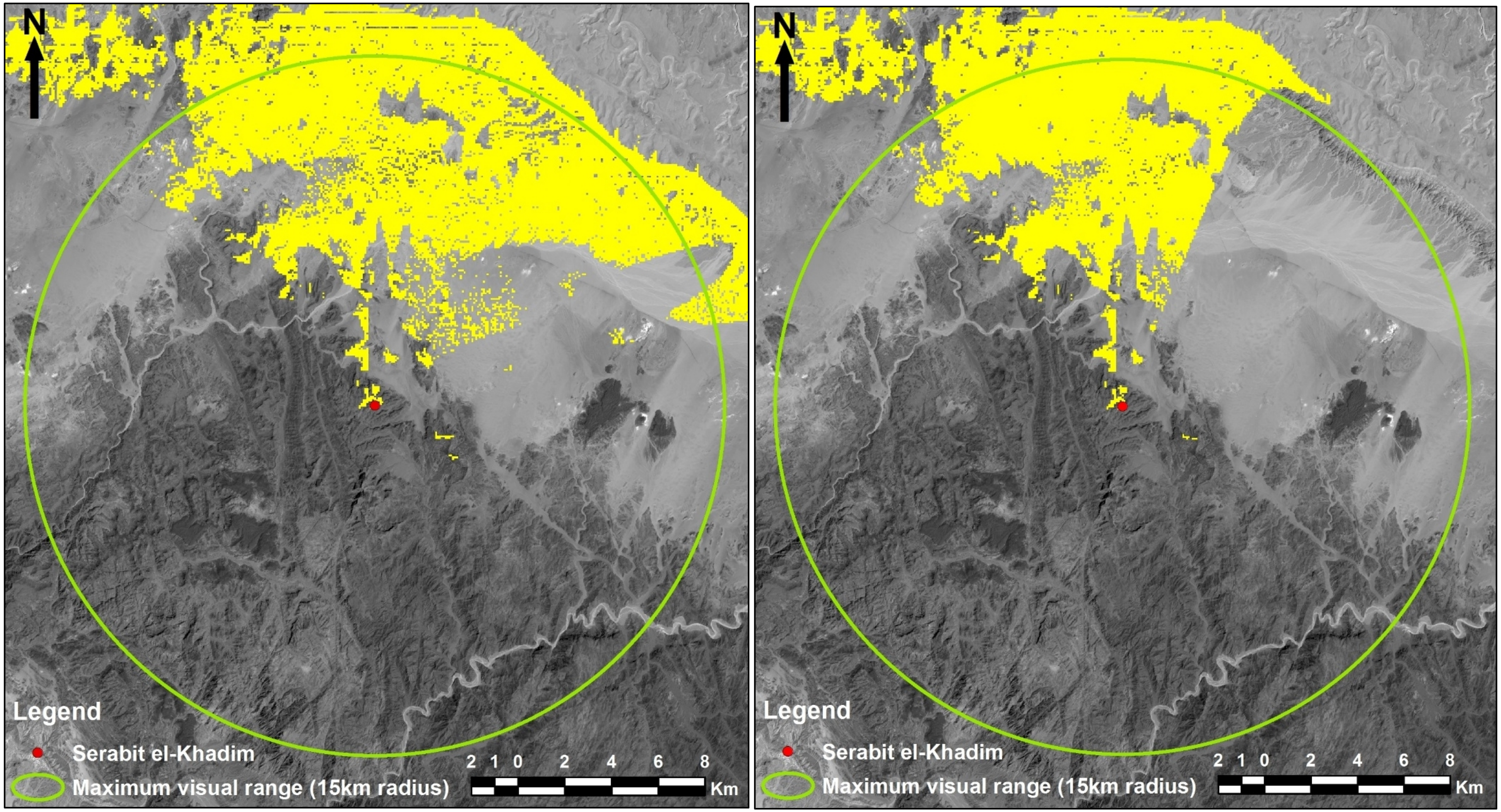


Fig 7.6: Viewsheds for SK3 a) Projective viewshed showing what was visible to SK3 (left) and b) Reflective viewshed showing where SK3 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

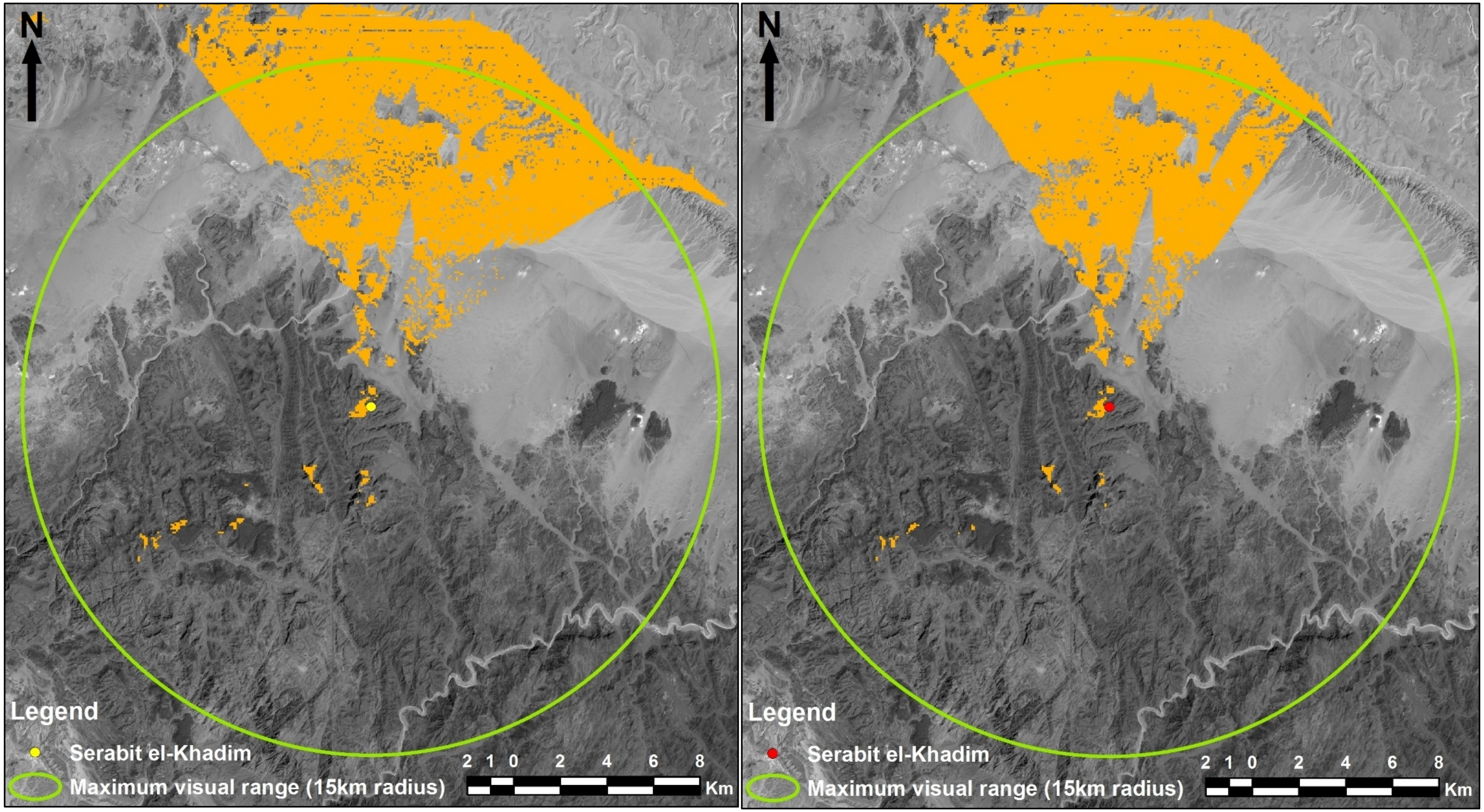


Fig 7.7: Viewsheds for SK4 a) Projective viewshed showing what was visible to SK4 (left) and b) Reflective viewshed showing where SK4 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

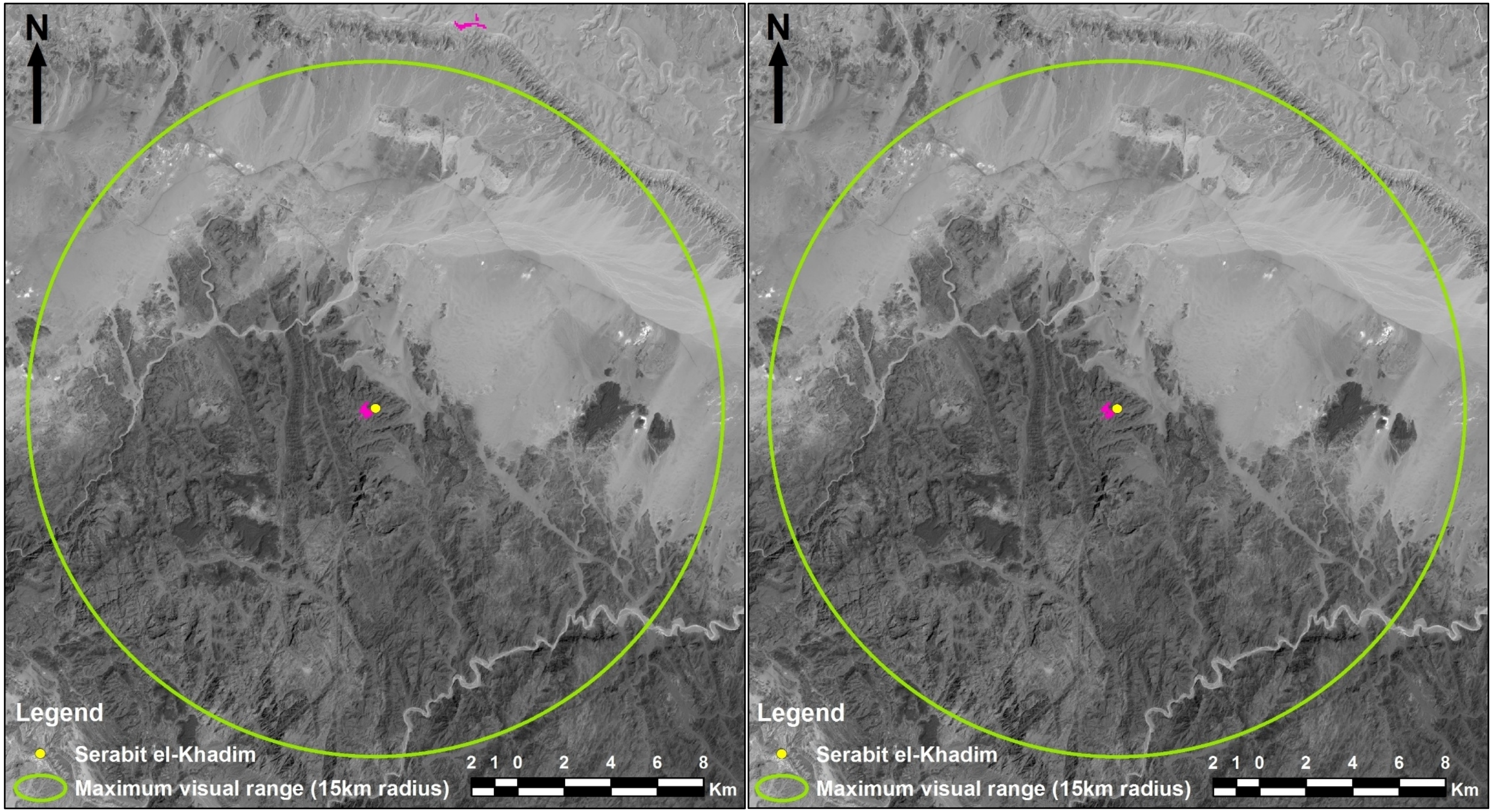


Fig 7.8: Viewsheds for SK5 a) Projective viewshed showing what was visible to SK5 (left) and b) Reflective viewshed showing where SK5 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

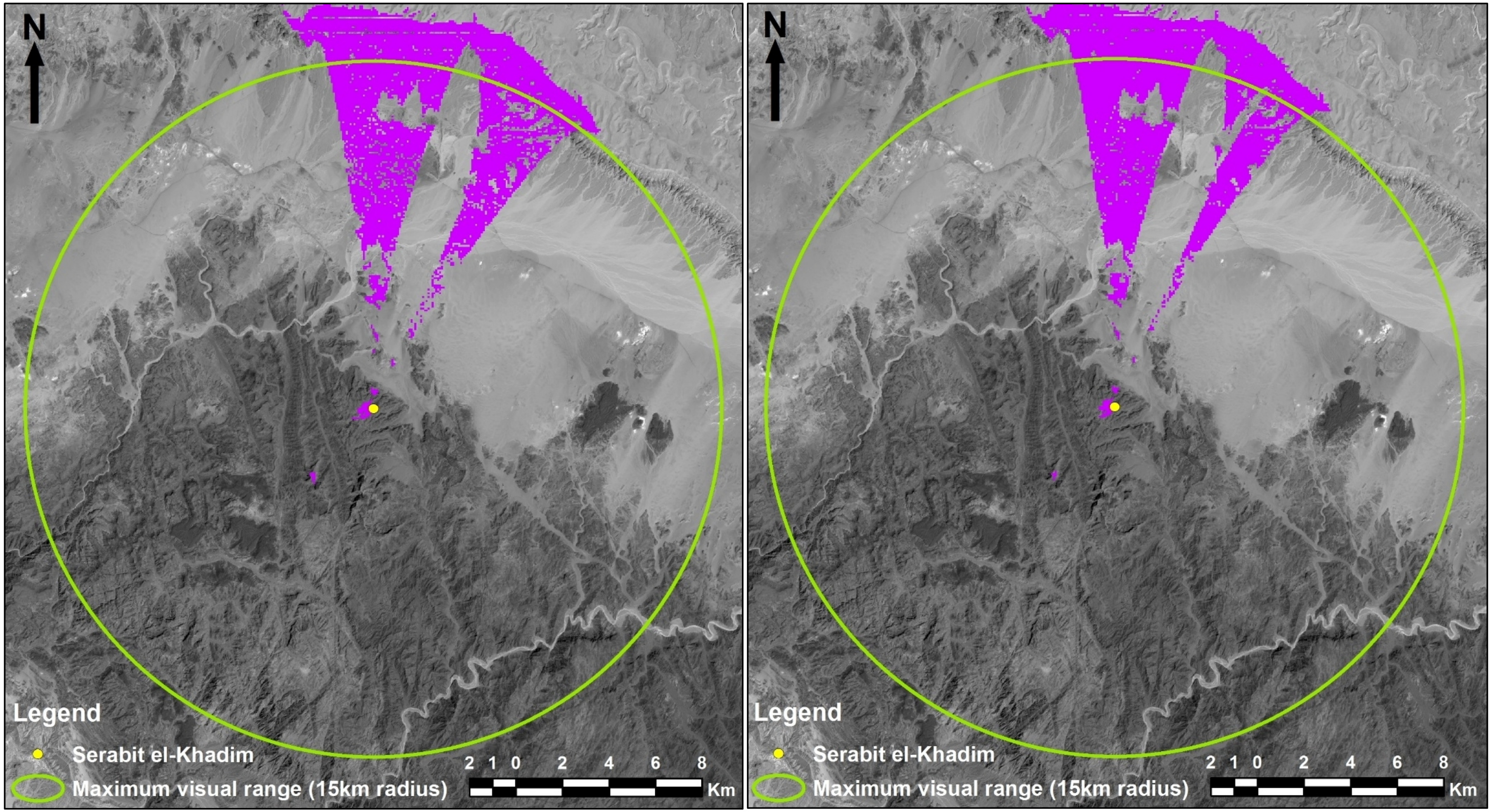


Fig 7.9: Viewsheds for SK6 a) Projective viewshed showing what was visible to SK6 (left) and b) Reflective viewshed showing where SK6 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

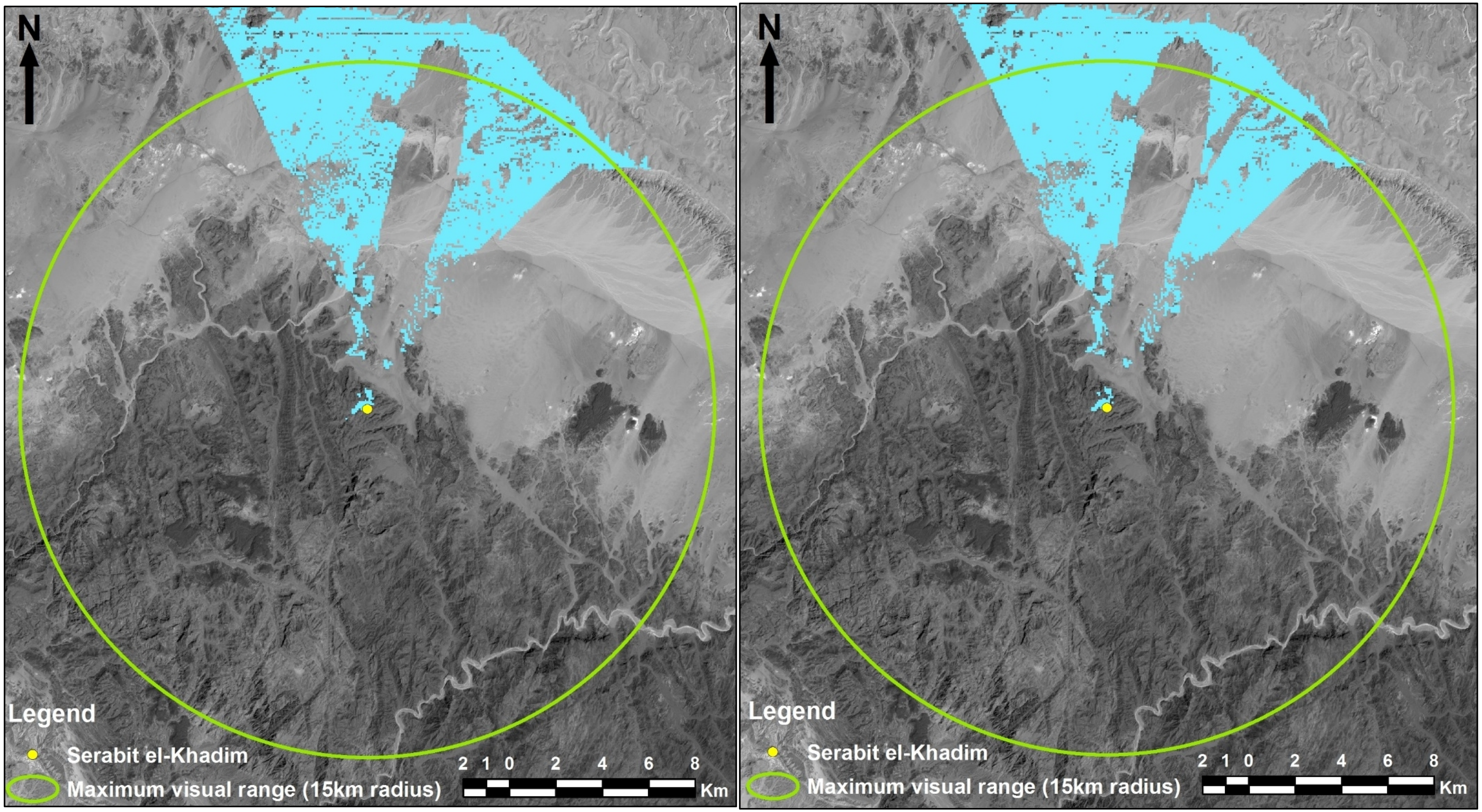


Fig 7.10: Viewsheds for SK7 a) Projective viewshed showing what was visible to SK7 (left) and b) Reflective viewshed showing where SK7 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

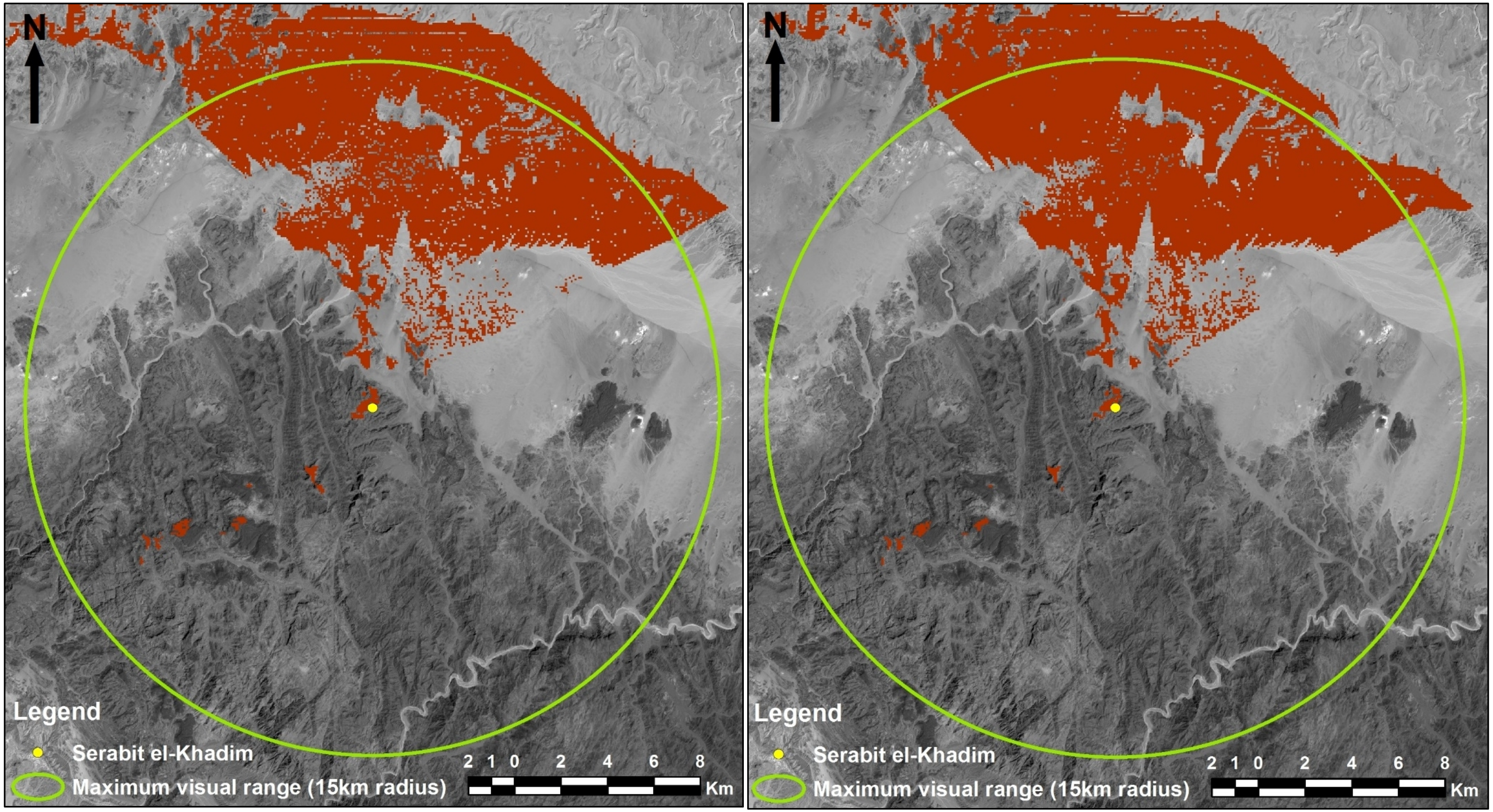


Fig 7.11: Viewsheds for SK8 a) Projective viewshed showing what was visible to SK8 (left) and b) Reflective viewshed showing where SK8 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

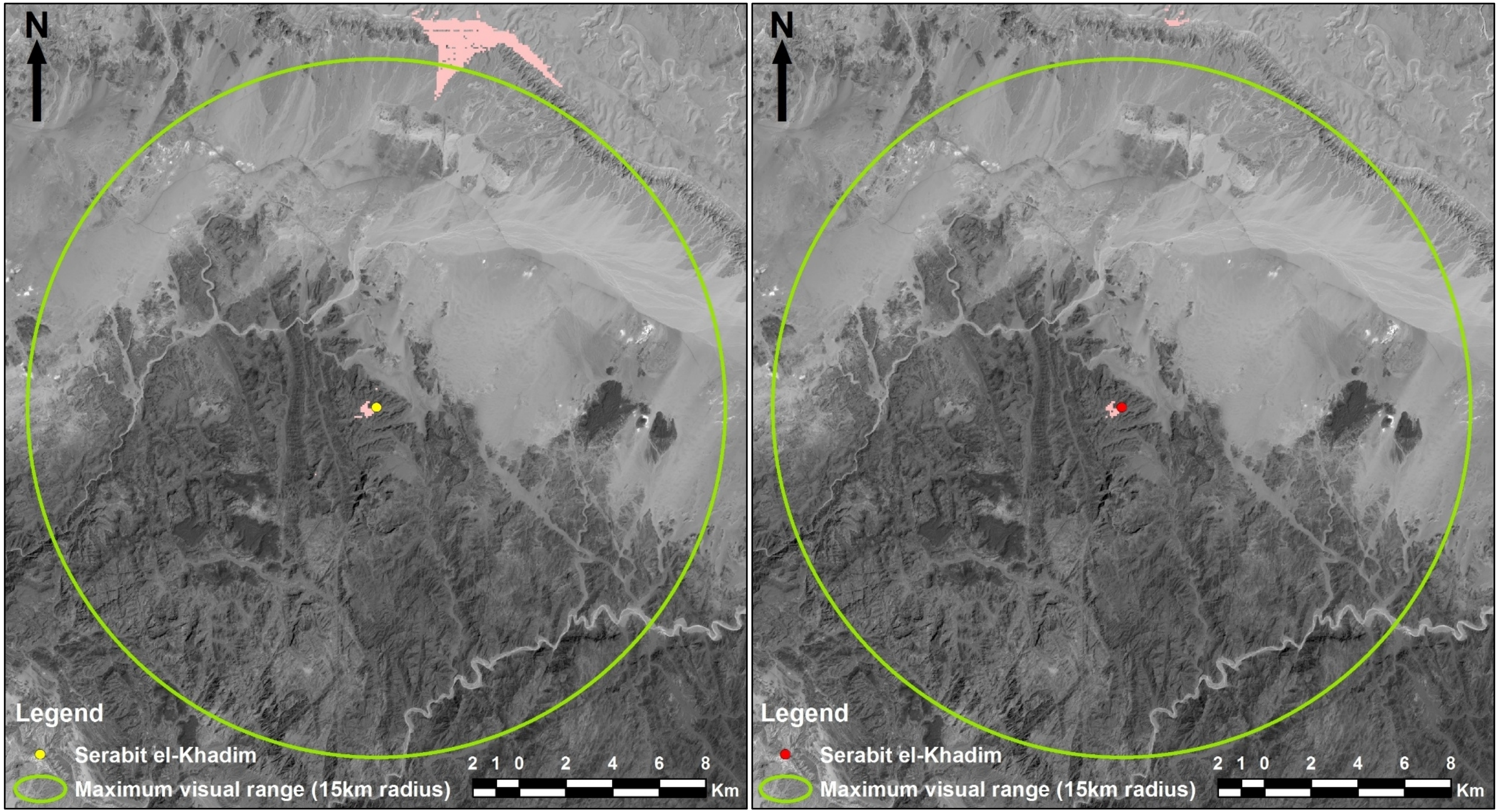


Fig 7.12: Viewsheds for SK9 a) Projective viewshed showing what was visible to SK9 (left) and b) Reflective viewshed showing where SK9 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

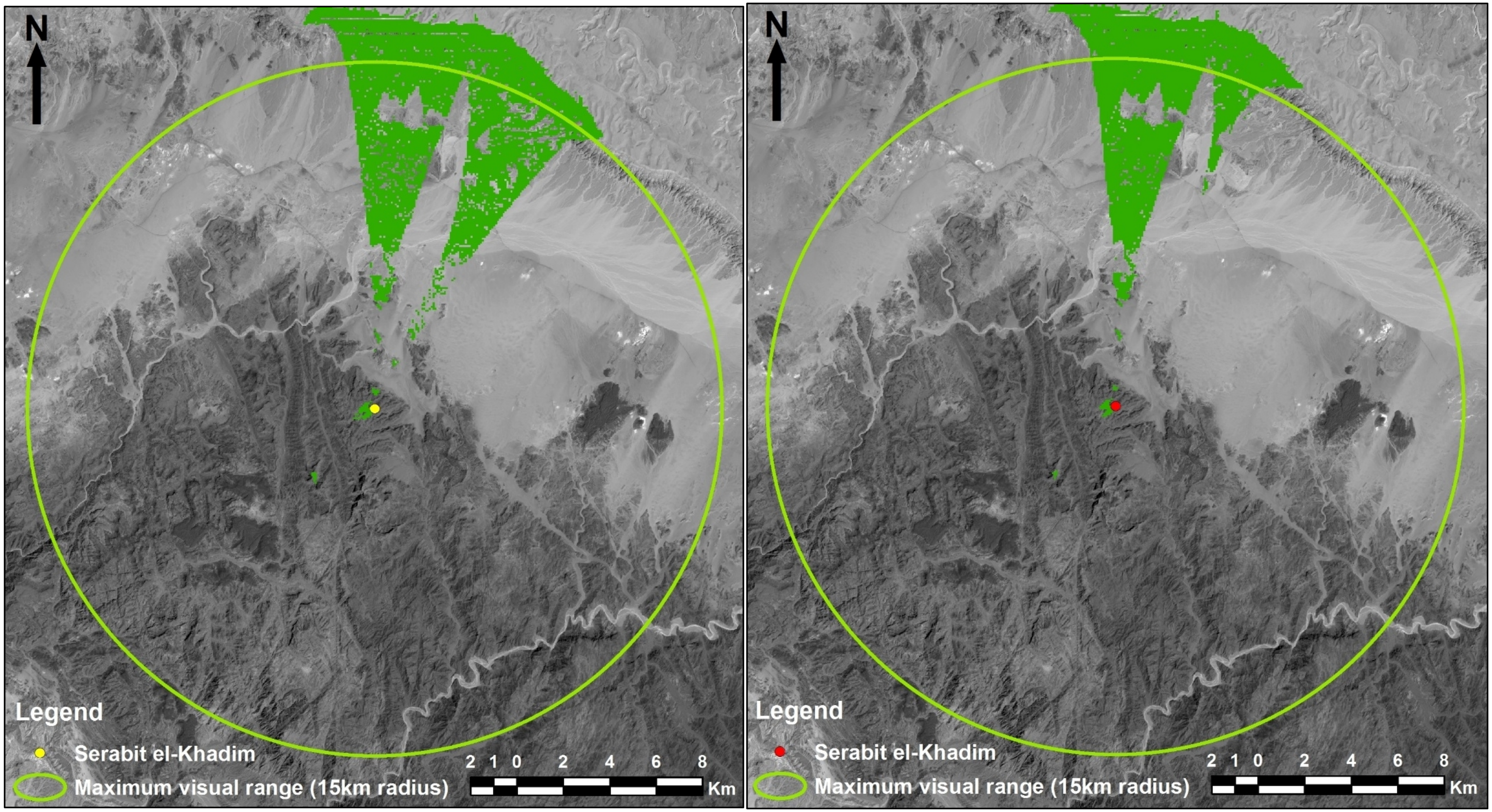


Fig 7.13: Viewsheds for SK10 a) Projective viewshed showing what was visible to SK10 (left) and b) Reflective viewshed showing where SK10 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

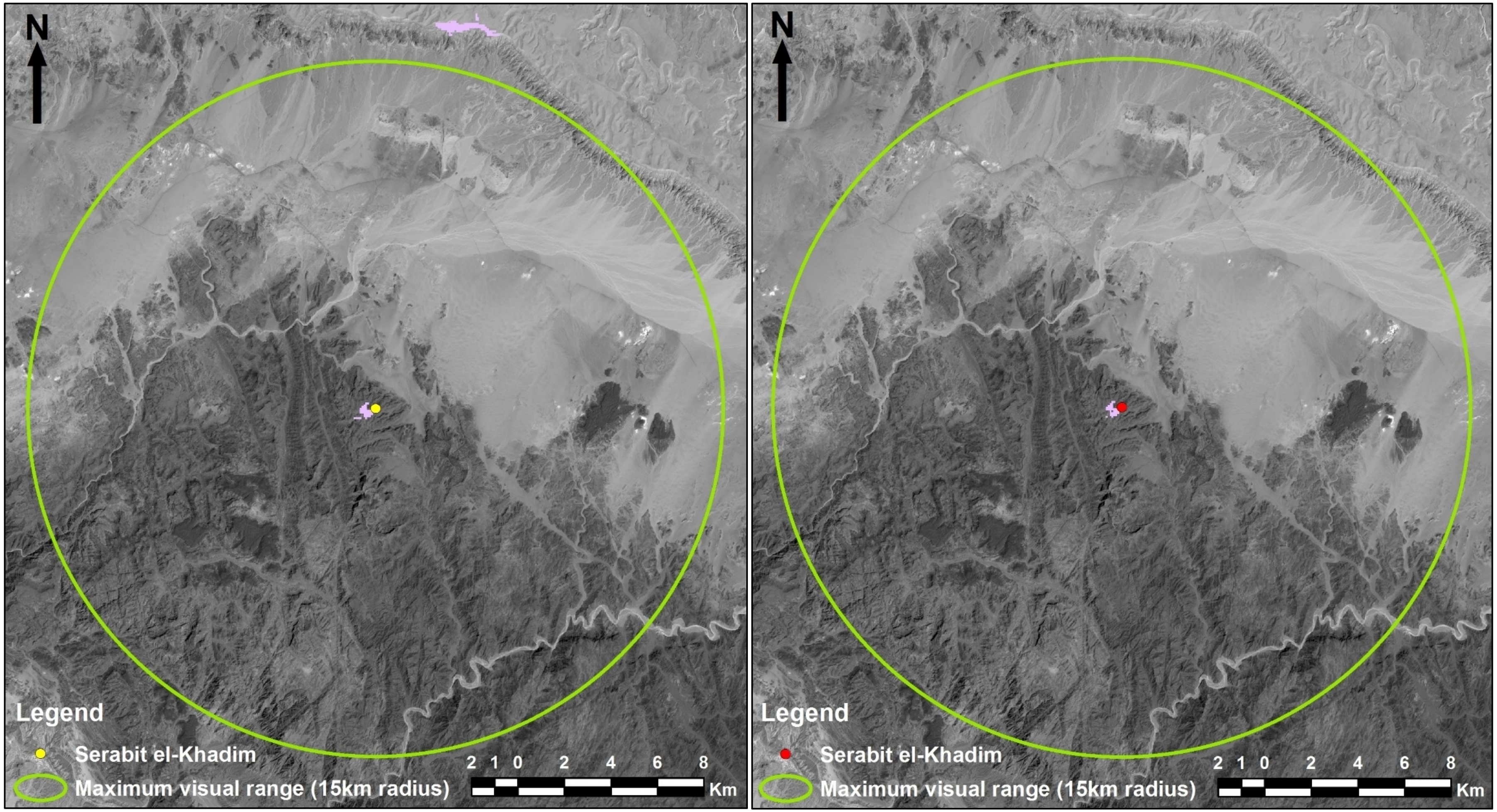


Fig 7.14: Viewsheds for SK11 a) Projective viewshed showing what was visible to SK11 (left) and b) Reflective viewshed showing where SK11 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

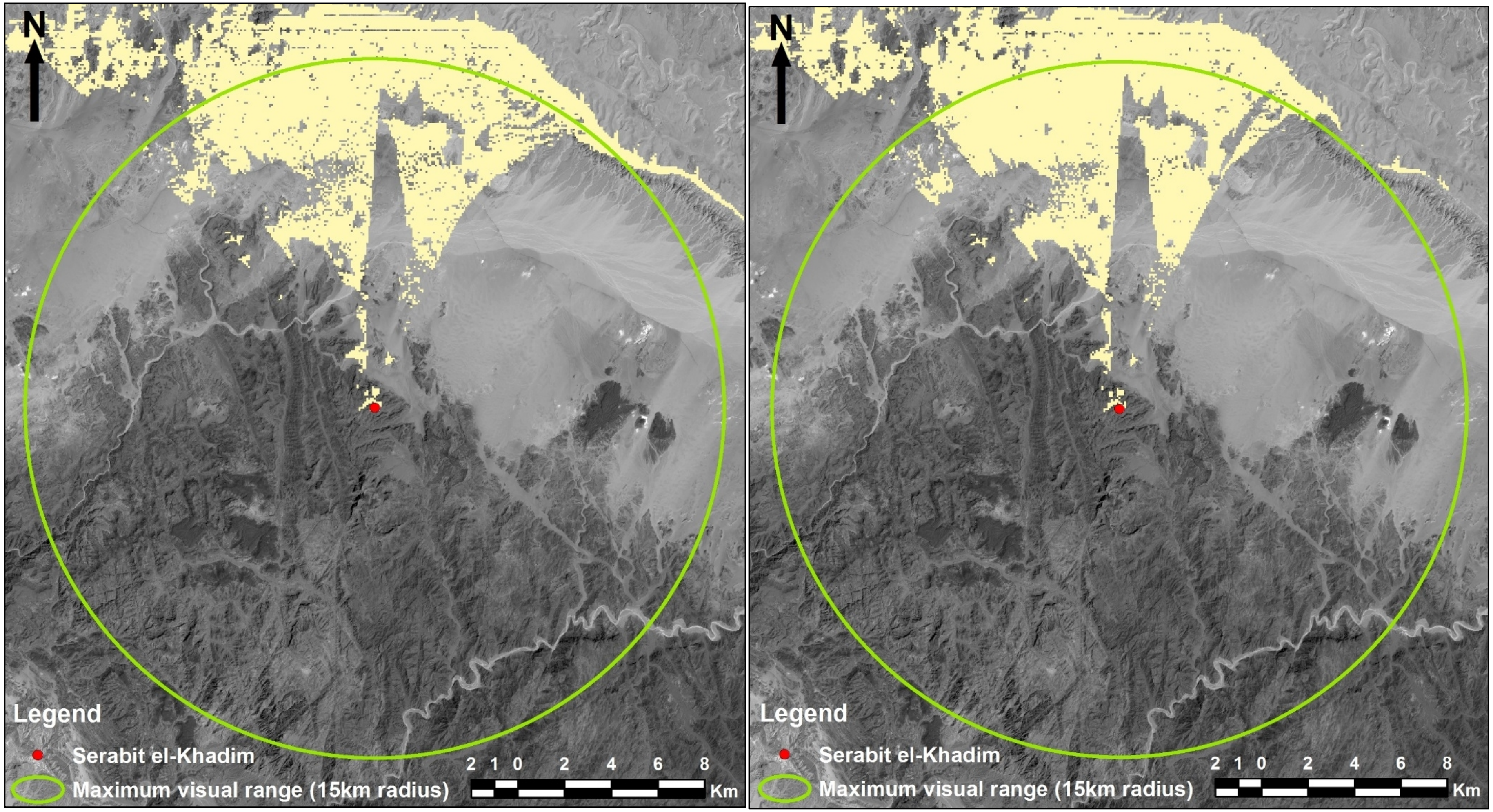


Fig 7.15: Viewsheds for SK12 a) Projective viewshed showing what was visible to SK12 (left) and b) Reflective viewshed showing where SK12 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

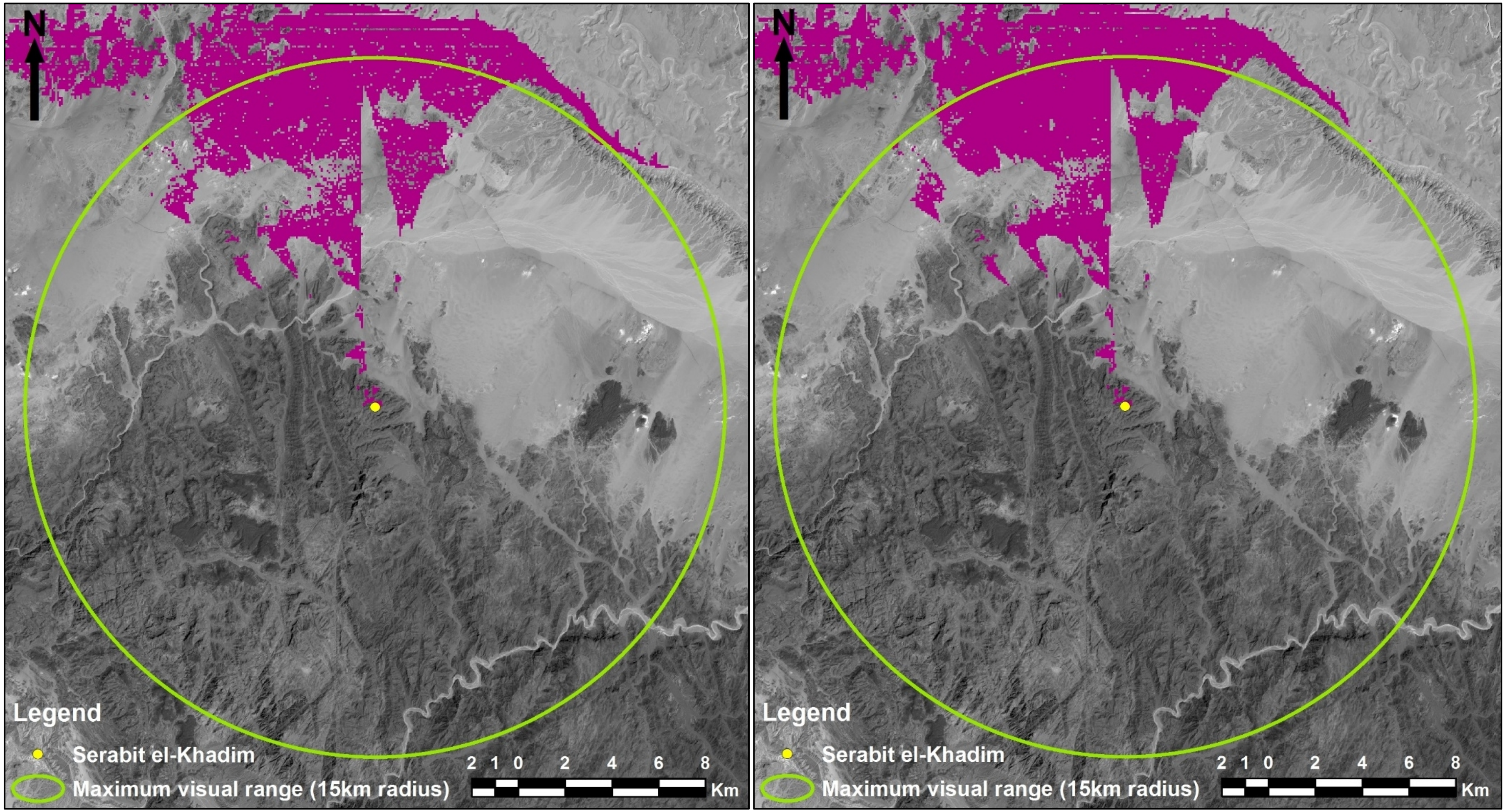


Fig 7.16: Viewsheds for SK13 a) Projective viewshed showing what was visible to SK13 (left) and b) Reflective viewshed showing where SK13 was visible (right), shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

Table 7.2: Sizes of projective and reflective viewsheds of SK1–SK13 at Serabit el-Khadim.

Observer point	Date	Nature	Projective			Reflective		
			Raster cells		Rank	Raster cells		Rank
			Number	Area (km^2)		Number	Area (km^2)	
SK1	Senusret I	Stela 66	947	7.08	10	96	0.72	10
SK2	Senusret III	Stela 82	21625	161.66	2	22352	167.09	1
SK3	Senusret I/ Amenemhat II	Stela 403/ 404	22343	167.02	1	14585	109.03	3
SK4	Amenemhat II	Stela 73	16270	121.62	4	13455	100.58	4
SK5	Late Middle Kingdom	Stela 133	36	0.27	13	37	0.28	13
SK6	Late Middle Kingdom	Stela 138	6543	48.91	9	6121	45.76	8
SK7	Late Middle Kingdom	Stela 147	10235	76.51	7	10698	79.97	6
SK8	Amenemhat II	Stela 74	19678	147.10	3	19930	148.98	2
SK9	Undated	Enclosure	277	2.07	11	41	0.31	11
SK10	Undated	Enclosure	6948	51.94	8	4615	34.50	9
SK11	Senusret III	Stela 146	40	0.30	12	39	0.29	12
SK12	Amenemhat II	Shrine of Kings	13273	99.22	5	13087	97.83	5
SK13	Senusret I	Hathor hill	10763	80.46	6	10224	76.43	7

In general the viewsheds are largely reciprocal, with reflective viewsheds being generally similar to projective viewsheds in shape and size. There is only 0.7km^2 difference between the largest projective and the largest reflective viewsheds, and only 0.01km^2 between the smallest projective and smallest reflective viewsheds.

Mean projective viewshed size is 74.17km^2 and mean reflective viewshed size is 66.29km^2, reflecting the influence of SK3, SK4 and SK10, which all have substantially larger projective viewsheds than their reflective viewsheds. Chart 7.1 shows the areas of the projective and reflective viewsheds plotted against each other for each SK observer point, demonstrating the correlation between the projective and reflective viewsheds and their generally reciprocal nature.

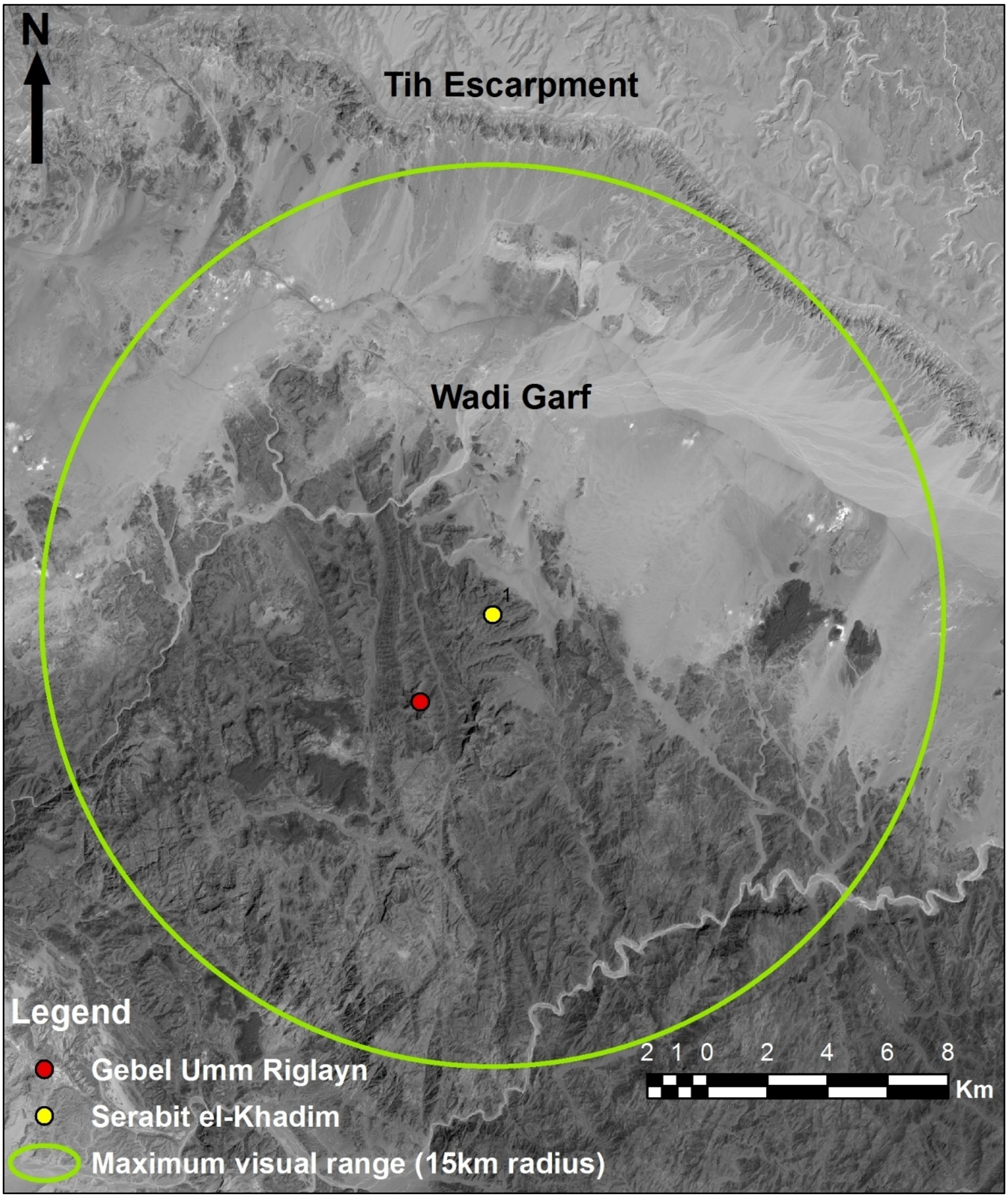
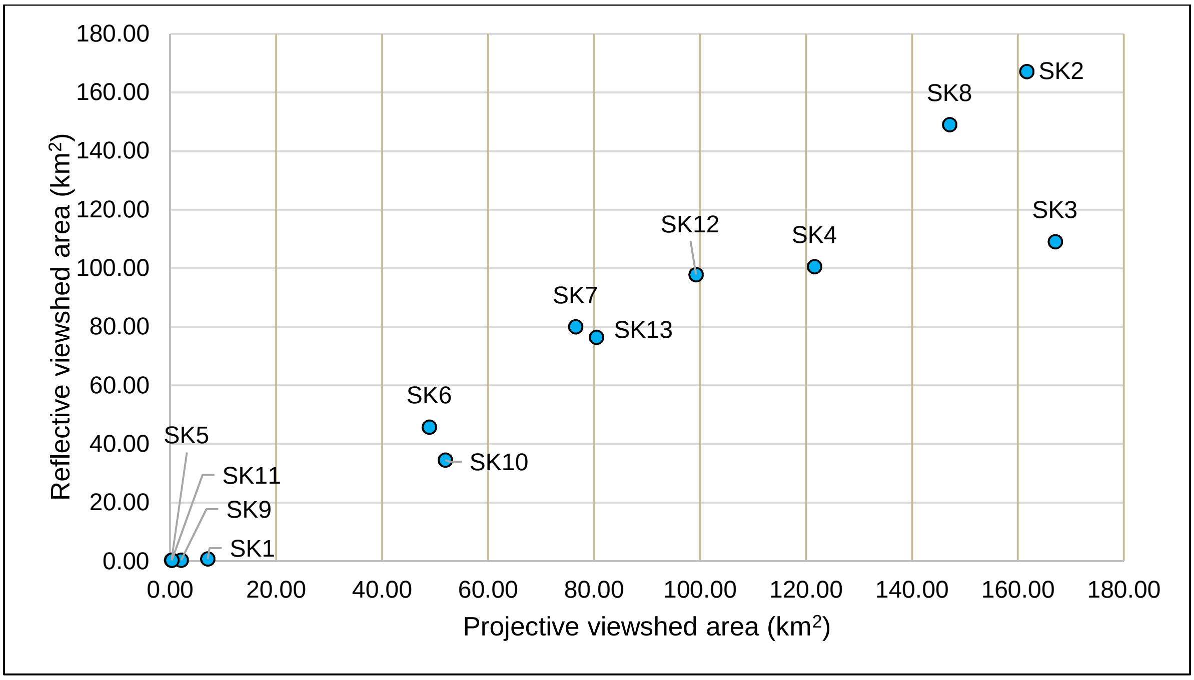


Fig 7.17: Significant landscape features visible in the viewsheds of observer points SK1–SK13 at Serabit el-Khadim, shown overlying Landsat 8, Band 8 15m resolution image LC81750402013093LGN01 from 2013 (Landsat data from the USGS).

Chart 7.1: The viewsheds for SK1–SK13 plotted to show the correlation in size between the projective and reflective viewsheds. Made with data from Table 7.2.



The viewsheds for the 13 SK observer points reveal considerable variety in size (Table 7.2), with viewshed sizes ranging from 0.27km^2 to 167.09km^2. Within this range 3 groups can be discerned:

1. The first group comprises observer points SK1 (Fig 7.4), SK5 (Fig 7.8), SK9 (Fig 7.12) and SK11 (Fig 7.14), which have the smallest viewsheds and are ranked 10th, 13th, 11th and 12th respectively in Table 7.2. Both projective and reflective viewsheds associated with these observer points are smaller than 10km^2, most of them are smaller than 5km^2 and both the projective and reflective viewsheds of SK5 and SK11 are smaller than 0.5km^2. This group appears as a very distinctive cluster in Chart 7.1.
2. The second group includes the observer points with the largest viewsheds, SK2 (Fig 7.5), SK3 (Fig 7.6), SK4 (Fig 7.7) and SK8 (Fig 7.11) are ranked 1–4 in Table 7.2 and appear at the top right of Chart 7.1. Although their reflective viewsheds are not necessarily the same rank as their projective viewsheds, they occupy the top 4 positions for both projective and reflective viewsheds. Both the projective and reflective viewsheds associated with these observer points are greater than 100km^2.
3. The remaining observer points have projective and reflective viewsheds greater than 10km^2 but less than 100km^2. This is the most varied group. At only just under 100km^2 both projective and reflective viewsheds of SK12 (Fig 7.15) are ranked 5th, while the smallest viewshed in the group is 34.50km^2 (Fig 7.13). SK7 (Fig 7.10) and SK13 (Fig

7.16) have one viewshed ranked 6th and one ranked 7th, while SK6 (Fig 7.9) and SK10 (Fig 7.13) share 8th and 9th place in a similar fashion.

Location and visibility

Review of the layout of the SK observer points (Fig 7.2) reveals that the first group of observer points (SK1, SK5, SK9 and SK11), with the smallest viewsheds, comprise a group located farthest from the Hathor temple at the western end of the plateau. This far group of archaeological features and stelae were identified by Valbelle and Bonnet (1996, 70–73) as the third of three groups of stelae, which defined the axis of approach to the temple. Based on the dating of the stelae in these groups, Valbelle and Bonnet determined that an early southern axis, inaugurated during the reign of Senusret I, was later replaced in the late Middle Kingdom by a more northerly axis that terminated in the temple sanctuary and the Shrine of Kings, both of which were heavily embellished with stelae and other constructions during the late Middle Kingdom reigns of Amenemhat III and IV (Fig 7.18). Stelae from both the earlier southern axis and the later northern axis are included in each of the three groups located along the approach to the temple:

1. The group nearest to the temple, comprising stelae 403 and 404 and represented by SK3. Based on stylistic and textual parallels 403 was the earliest stela, dating to the reign of Senusret I, and marking the early southern axis of approach towards the Hathor hill. It was joined by stela 404 during the reign of Amenemhat II. Stela 147 (SK7) would be consistent with a very extreme northerly axis, but may be unrelated to the approach to the temple.[353]

---

[353] This is consistent with Valbelle and Bonnet's (1996, 72) interpretation of stela 147 as a late Middle Kingdom stela associated with facilities constructed for the Hathor sanctuary during the reign of Amenemhat III. In addition to the stelae marking the approach to the temple and those within it, a variety of other stelae were found across the landscape at the entrances to mines (Valbelle and Bonnet 1996, 60–63), along various paths (Petrie 1906, 63) and at small shrines (Valbelle and Bonnet 1996, 66–67). These stelae have not been included in this research as no plan of their position has been published, but their existence reveals that stelae and shrines of various types were associated with locations other than the temple and its approach. Thus stela 147, and perhaps 138, which are located off the main axis of the approach, are likely to be examples of these other stelae, rather than belonging to the near, middle and far groups marking the approach to the temple.

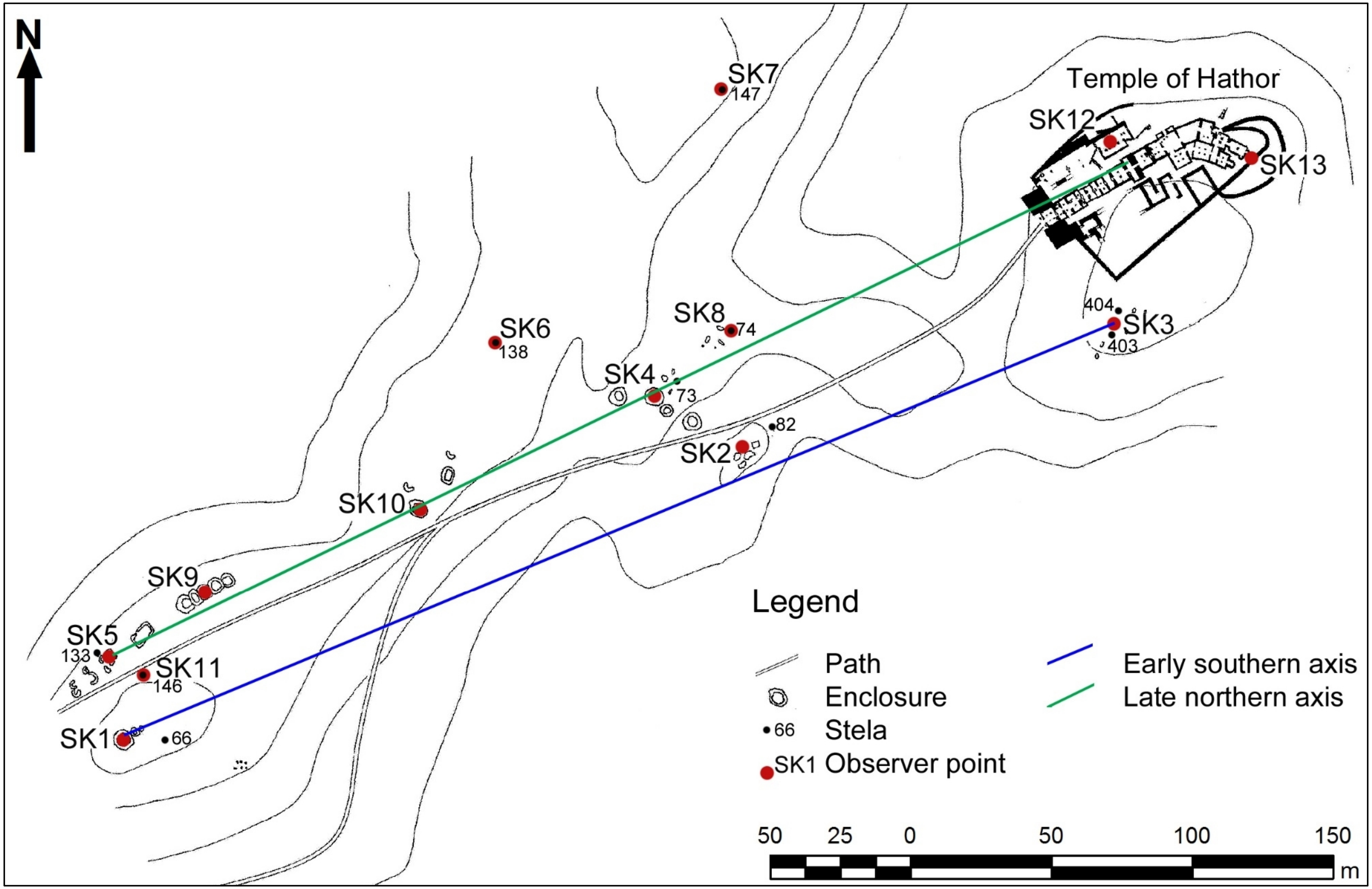


Fig 7.18: The two axis of approach to the temple (Base plan adapted and georeferenced from Valbelle and Bonnet 1996, plan 1).

2. A middle group comprising stelae 73 (SK4), 74 (SK8), 82 (SK2) and, possibly, 138 (SK6), marking a mid-point along the approach. The earliest surviving stelae in this group date from the reign of Amenemhat II, when stela 73 and 74 were erected. Although stela 82 was erected during the reign of Senusret III, the archaic style harks back to the reign of Senusret I (Valbelle and Bonnet 1996, 71). This might suggest a desire to 'complete' Senusret I's southern axis, which ran from stela 66 to stela 403 (Fig 7.18). Stela 138 was difficult to interpret (Valbelle and Bonnet 1996, 72–73). It is consistent with a more northerly axis, but like stela 147 its location may be due to some other factor and it may not be related to the stelae along the approach to the temple.
3. A far group comprising stelae 66 (SK1), 133 (SK5) and 146 (SK11), located just before the path drops off the plateau into the valley. Initially created during the reign of Senusret I, with stela 66 marking the far end of the approach to the Hathor hill. This location was enhanced by stela 146, in the reign of Senusret III. The northerly movement of the axis in the later Middle Kingdom is represented by stela 133.

Together with SK9, which was not associated with any known stelae, Valbelle and Bonnet's far group of stelae 66, 133 and 146 are all represented by observer points (SK1, SK5 and SK11) with very small viewsheds of less than 10km^2. The middle group of stelae 73, 74 and 82 are represented by observer points (SK2, SK4 and SK8) with very large viewsheds greater than 100km^2. Stela 138 (SK6) has viewsheds of 48.91km^2 and 45.76km^2, but as it is some distance (*c.* 45m) from the approach to the temple it is unlikely to be associated with the group of stelae and enclosures on the temple approach. Of the features nearest the temple, stelae 403 and 404, represented by SK3, have large viewsheds of over 100km^2. Stela 147 (SK7) has much smaller viewsheds of 76.51km^2 and 79.97km^2, but is located *c.* 90m off the northern axis and, like stela 138, is probably not associated with the groups of stelae marking the approach.

Thus if the slightly anomalous stelae 147 and 138 are excluded from the near and middle groups respectively, all the stelae in both these groups exhibit comparatively large viewsheds, while all the stelae in the far group have very small viewsheds. These differences are very clearly correlated with the location of these groups. SK1, SK5, SK9 and SK11 are simply located in a less prominent part of the landscape than the observer points closer to the temple. SK10 has viewsheds of 51.94km^2 and 34.50km^2 and is located between the far group, with small viewsheds under 10km^2, and the middle group, with large viewsheds of over 100km^2. The viewsheds of this intermediate point at SK10 confirm that visibility increases with movement along the path towards the temple, specifically between the far group of SK1, SK5, SK9 and SK11 and the middle group of SK2, SK4 and SK8.

Increasing visibility with movement along the path towards the temple might have been a contributing factor in the creation of the sacred space in this area. The view opens up as a person moves from the restricted views (Fig 7.4; Fig 7.8; Fig 7.12; Fig 7.13) at the farthest group of stelae (SK1, SK5, SK9 and SK11), towards the middle and near groups (SK2, SK4, SK8 and SK3), with their large views northwards (Fig 7.5; Fig 7.7; Fig 7.11 and Fig 7.6). Although they do not have the largest viewsheds, observer points SK12 (Fig 7.15) and SK13 (Fig 7.16), within the temple, still have good views and are inter-visible with the large valley of the Wadi Garf and the distant escarpment and Tih plateau, which dominate all the viewsheds above $10km^2$ and are the most imposing topographic features in this area (Fig 7.17; Fig 7.19).

Fig 7.19: Google Earth ground-view image showing the view northwards from approximately SK13, the Hathor hill. The topography is based on the SRTM digital elevation model and the overlying satellite imagery is from 2013. Terrain elevation at the viewpoint is 753m.

Stela 403 (SK3; Fig 7.6) has larger viewsheds than SK12 and SK13 suggesting that visibility was a more important factor in the layout of the ritual features in the earliest period, prior to the focus on the temple proper. Stela 403 is dated to the reign of Senusret I and reveals that the small hill south of the temple was an early focus of ritual activity, prior to a renewed focus on the Hathor hill in the reign of Amenemhat II and the construction of the rock-cut Hathor sanctuary in the reign of Amenemhat III.[354] Chart 7.1 and Table 7.2 show that stela 403 (SK3) was located in a more prominent location, with much larger viewsheds than the Hathor hill (SK13). Since the Hathor hill later became the focus of the temple and the location for the sanctuary, it is clear that having the best view or being the most visible location was not the

[354] The most recent excavations at the site revealed that although the enclosure of Senusret I included the Hathor hill, the earliest structures in front of it date to the reign of Amenemhat II. The construction of the rock-cut sanctuary is dated to the reign of Amenemhat III (Valbelle and Bonnet 1996, 82–85). Thus the intensive focus upon the Hathor hill was a later feature of the development of the temple and not an early initiative of Senusret I.

primary factor in the positioning of the sanctuary, otherwise it would surely have been located at SK3 or further west on the hill at SK2 (Fig 7.5), which actually has the largest combination of projective and reflective viewsheds (Chart 7.1 and Table 7.2). The choice of the Hathor hill for the sanctuary, rather than SK3, may have been due to the presence of an existing natural fissure or overhang that was later expanded into the rock-cut sanctuary.[355]

Navigation and visibility

The results of the visibility analysis revealed that there is a strong relationship between the area of the plateau and the visibility of the observer points. Those observer points located at the western end of the plateau within the far group of stelae and enclosures are associated with very small viewsheds of under 10km^2, while the middle and near groups are associated with much larger viewsheds, typically over 100km^2. It is therefore possible that the three groups were located to provide appropriate navigational markers to assist those moving across the plateau towards the temple.

On the return away from the temple, navigational markers would have been even more important because travellers were aiming for an ephemeral path rather than a structure. The three groups of enclosures and stelae may have assisted travellers in moving confidently across the plateau towards the path into the valley. The use of such features for navigation would be consistent with the evidence from Stelae Ridge and elsewhere, where various different types of landmarks were used to mark routes across the desert at intervals that ensured there could be no doubt about the correct route.[356]

In addition to the stelae and stone enclosures, travellers moving away from the temple from the middle group of observer points may also have made used of the twin peaks of Gebel Umm Riglayn as a further natural landmark. Observer points SK2, SK4 and SK8 in the

---

[355] Elsewhere in Egypt there is an association between shrines and temples and rock overhangs, caves, fissures and natural niches. At Elephantine the temple of Satet was initially located in a niche between large boulders (Dreyer 1986; Kemp 2006, 116–121); at Deir el-Medina the shrine to Meretseger was located around a rocky overhang (Teeter 2011, 84-86); at Deir el-Bahri there were several rock-cut shrines, including a Middle Kingdom sanctuary of Hathor (Arnold 1974, 83–84; Naville 1907, 63; 1910, 7; Pinch 1993, 4–6). The mining sites of Gebel el-Zeit (Castel and Soukiassian 1985a) and Timna (Rothenberg 1988) both had rock-cut shrines; and Gebel el-Silsilah contains numerous rock-cut shrines associated with quarrying (Bommas 2003; Caminos and James 1963). Williams (2006) considers wider usage of caves and rock-shelters for ritual purposes across north-east Africa.

[356] Riemer (2013) describes the use of upright stones as *alamat* or landmarks along the Old Kingdom Abu Ballas trail. Bubenzer and Bolton (2013) describe similar structures along the Darb el-Tawil and Storemyr *et al*. (2013) associated the same type of structure with roads in the quarrys on the West Bank at Aswan. Although the upright stones on the Abu Ballas trail, Darb el-Tawil and Aswan were uninscribed, vertically set stelae in enclosures at Serabit el-Khadim could have functioned as more formal versions of the same type of *alamat*.

middle group (Fig 7.5, Fig 7.7 and Fig 7.11), together with SK6 (Fig 7.9) and SK10 (Fig 7.13), have a view of the twin peaks of the Gebel Umm Riglayn (Fig 7.17), but none of the other observer points have a view of these peaks. Fig 7.3 shows how these peaks are located to the west of stela 66 (SK1) and provide a useful landmark.[357] Those returning from the temple and heading westwards along the ancient path that passes stela 66 could steer slightly to the right of the peaks, while anyone who wanted to turn southwards would only need to turn more directly towards the Gebel Umm Riglayn, particularly the more distant southerly peak.

The evidence for a navigational aspect to the stelae and courts along the approach to the temple is suggestive, but would benefit from more detailed visibility analysis of the plateau using a much higher resolution DEM than the SRTM used here. This would allow the visibility of the different groups of stelae to be examined to determine precisely from where on the plateau they could be seen, and what other structures could be seen from them.

It is also clear that the structures and stelae were not only landmarks, or there would be little point in having so many, inscribing the stelae or constructing such elaborate settings for them. A role for the stelae and enclosures as landmarks does not detract from the ritual and social aspects of these structures.[358] Rather it raises questions about the relationship between the use of the structures for navigation and the ritual and social functions implied by the texts and presentation of the stelae.

Dating and visibility

It has been suggested that visibility was important in the development of the sacred area, particularly in the orientation and focus of the earlier axis during the reign of Senusret I. Some slight correlation between date and visibility might also be implied by the observer points dating to the reign of Amenemhat II (SK4, SK8 and SK12), which vary in ranking and viewshed size, but all are ranked 5th or above (Table 7.2). Those observer points dating to the later Middle Kingdom (SK5, SK6 and SK7) are similarly varied, but none are ranked above 7th. Thus stelae or features dating to the earlier reign of Amenemhat II generally have

---

[357] Riemer's (2013, 96) study of the use of landmarks along the Abu Ballas Trail revealed that distinctively shaped hills could function as natural landmarks, particularly when they were in pairs. In Chapter 6, section 6.1.2 it was suggested that the notch in Twenty Cairn Ridge may have functioned as a similar natural landmark for those moving to or from the Stelae Ridge mines.

[358] Valbelle and Bonnet (1996, 118–123; 141–160) and Černy *et al.* (1955) discuss the various ritual and social aspects of the stelae from Serabit el-Khadim together with the evidence from other texts from the site. Other references to the ritual and social aspects of mining and quarrying inscriptions generally can be found in Blumenthal (1977); Darnell and Manassa (2013); Eichler (1994); Lloyd (2013); Seyfried (1982).

slightly larger viewsheds, while those erected in the later Middle Kingdom have generally smaller viewsheds. This is perhaps because earlier builders during the reign of Amenemhat II had a free choice of many good positions along the main axis approaching the temple, but these had been occupied by the later Middle Kingdom. It is not possible to say whether visibility *per se* or proximity to the axial approach was significant in the decision about the location of such features. Perhaps neither factor was particularly important during the later Middle Kingdom since two later Middle Kingdom stelae (138 and 147) with unexceptional viewsheds were situated some distance from the main axis and were probably not intended to form part of the groups along it.

Despite the generally better visibility associated with the stelae of Amenemhat II compared to those of the later Middle Kingdom, there is no consistent relationship between the date of an observer point and its visibility. SK1 (Fig 7.4) and SK3 (Fig 7.6) both date to the reign of Senusret I and define the western and eastern ends of the early axis. SK3 is highly visible and has one of the top two viewsheds, while SK1 has viewsheds of less than 10km^2 and is ranked 10th. Similarly, the two observer points SK2 (Fig 7.5) and SK11 (Fig 7.14) that date to the reign of Senusret III have very large and very small viewsheds and are ranked 1st and 12th respectively. Rational explanations can be made for both the limited visibility of the early SK1, which is associated with the more restricted visibility at the west end of the approach to the temple, and the very good visibility of the much later SK2, which has been interpreted as an attempt by later expeditions in the reign of Senusret III to ‘complete’ the axis created under Senusret I through installation of an archaising stela. However, the very variable visibility associated with stelae of both these pharaohs means it is impossible to be definitive about relationships between visibility and chronology and makes it difficult to use visibility to date the undated circular enclosures at SK9 and SK10.

Despite this it is worth pointing out that based on Valbelle and Bonnet’s model of the movement of the axial route approaching the temple, any stela which had originally been located in or associated with the circular enclosures around SK9 or SK10 would be expected to be of later Middle Kingdom date, reflecting the position of these enclosures on the later northern axis. A later Middle Kingdom date would also be generally consistent with the smaller viewsheds and low ranking of SK9 (Fig 7.12) and SK10 (Fig 7.13), but this is far from conclusive, given that SK1 is of very early date and also has a small viewshed and low rank. It is equally possible that SK9 and SK10 had alternative, perhaps non-ritual, functions. Any enclosures not associated with stelae could have been created as shelters for habitation and, given its location at the junction of two paths, SK10 might also have functioned as a navigation marker for those approaching the temple. Without further evidence it is impossible to date SK9 and SK10 or determine their function.

Conclusion

The rapid visibility analysis of the archaeological features at Serabit el-Khadim has revealed a number of interesting features of the site, which were not immediately apparent previously. The viewsheds associated with the archaeological features are generally restricted to the northern part of the landscape with a clear focus upon the Wadi Garf and Tih escarpment. The viewsheds clearly show that visibility increases as one approaches the temple. The far group of stelae and enclosures at the western end of the approach route to the temple have very restricted viewsheds, which are all under $10km^2$. Once travellers reached the middle group of stelae and enclosures, including that of Sobekherheb, visibility increased hugely with viewsheds of over $100km^2$, revealing the temple against the dramatic backdrop of the Wadi Garf and Tih escarpment.

The changing visibility as one approaches the temple also provides a rationale for the development of the groups of stelae and enclosures along the approach. The very large viewsheds of the middle group of stelae and observer points suggest that they were located in a prominent place, providing an intermediate landmark between the much more restricted visibility of the far group and the temple area. On the return journey, travellers leaving the plateau would also have the advantage of the distinctive Gebel Umm Riglayn to guide them away from the middle group of stelae.

Although there is a general relationship between earlier stelae and larger viewsheds, this is far from consistent for all the archaeological features and cannot be used to date undated stelae or enclosures. The better visibility of earlier stelae is probably only archaeologically significant in as much as it applies to stelae 403 and 404, which are very close to the temple and probably formed part of the earlier ritual area developed under Senusret I prior to the development of the Shrine of Kings and Hathor sanctuary. Although the early stela 403 and 404 have very large viewsheds, the Hathor hill and Shrine of Kings inside the temple have quite limited views and are not particularly visible from outside. Thus while visibility was important in the location of stela 403 during the early phase of Middle Kingdom activity, by the time construction was focussed upon the Hathor hill other factors were more significant. These factors might be related to the presence of an existing cave or fissure in the Hathor hill or to a new imperative towards seclusion, which perhaps arose as the Hathor hill was developed into a more typical Egyptian sanctuary, associated with seclusion and hiddenness.

7.4.3. Hatnub

The travertine quarry at Hatnub was discovered in 1891 by Howard Carter and Percy Newbery, although the name had long been known from Egyptian texts. The earliest discussion of the site and map of its location was published by Petrie (1894, 3–4) as part of his work at Amarna. A subsequent plan of the site was created by Paul Timme during a survey of the Amarna area (Timme 1917). The most detailed archaeological survey, together with some excavation, was undertaken between 1985 and 1994 (Shaw 2010). The publication of this work included maps of the large area of habitation around Quarry P, including a number of cairns and shrines (Shaw 2010, Fig 3.8; Fig 3.12; Fig 3.16; Fig 3.19; Fig 3.21; Fig 3.22; Fig 3.28).

The structures recorded by Shaw (2010) are all associated with Quarry P, the largest of the travertine quarries. They extend across an area *c.* 1.8km long and at least *c.* 800m wide, mostly to the west and south of Quarry P, and primarily include areas of habitation or travertine working. The cairns and shrines are spread throughout the settlement and the orthostats appear to be mostly located to the south and west, although the precise locations of the latter are not shown on the published plans (Fig 7.20 and Fig 7.21).

Observer points

The overall plan of the archaeological features recorded in the 1985–1994 survey and published by Shaw (2010, Fig 3.8) was georeferenced using the method described in section 7.4.1. The resulting rectified plan had an RMSE of 9.87m.

The rapid visibility analysis of Hatnub only includes the cairns and shrines surveyed in 1985–1994 and recorded in the plans published by Shaw (2010). Any ritual features mentioned but not shown on the published plans have been excluded, including orthostats S42–S57 and feature N20 (Shaw 2010, 41). Habitation sites and work areas shown on the plans have been excluded from the visibility analysis, because there are far too many to include and they are not typologically comparable with the cairn-shrines at Stelae Ridge or the stelae and enclosures at Serabit el-Khadim.

Based on Shaw’s plan, 16 observer points were created, representing the ten cairns and ten shrines shown on Fig 7.20 and Fig 7.21. The observer points are listed in Table 7.3 and shown on Fig 7.22. Observer points HB1–10 represent cairns and HB11–17 represent shrines. Where two or more shrines were located close together at S2 and S5, S11a–c, and NN9 and NN10, they are represented by a single observer point.

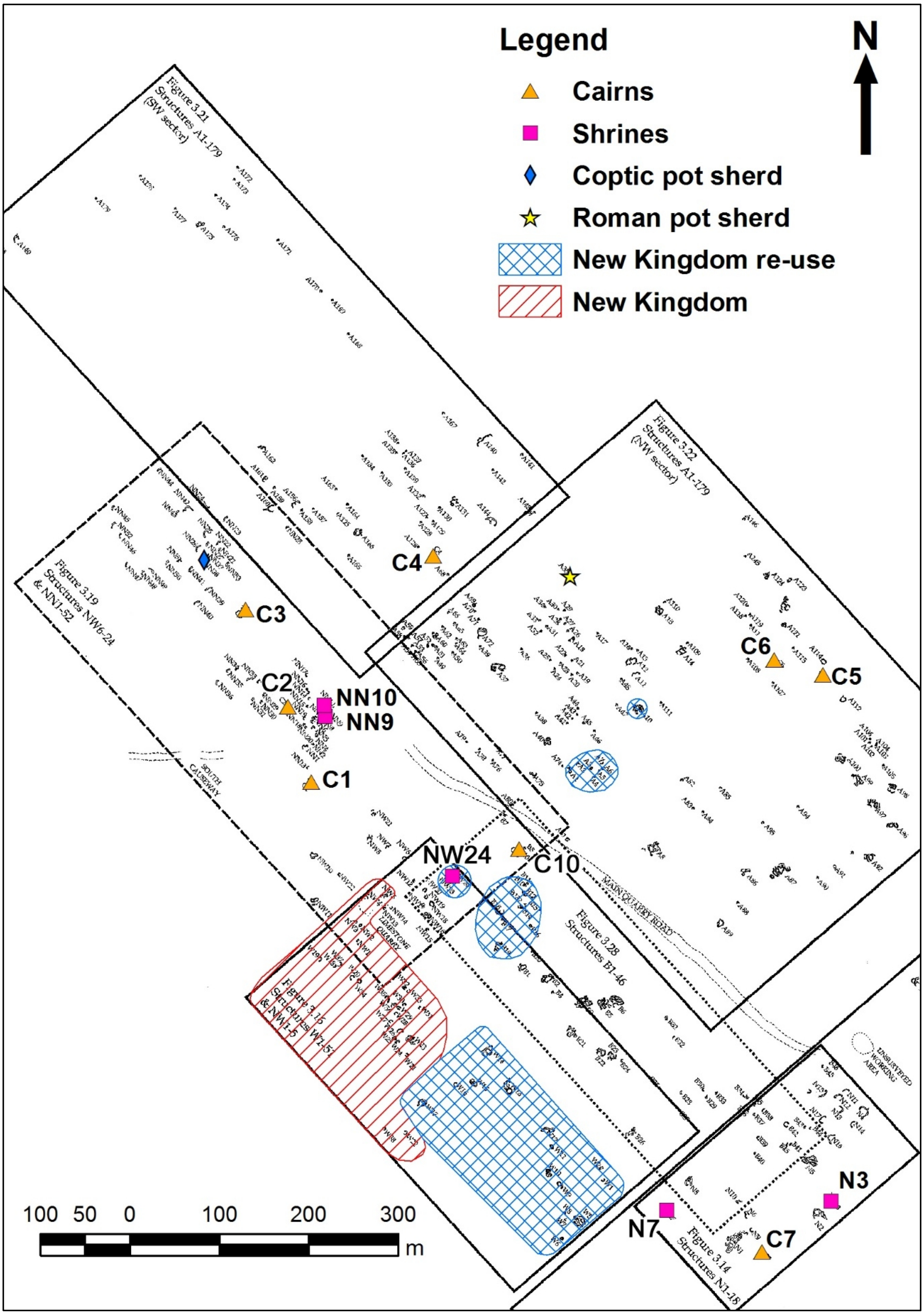


Fig 7.20: The northern section of the Old Kingdom settlement along the approach to Quarry P showing cairns, shrines, areas of New Kingdom habitation and re-use of Old Kingdom structures (Adapted and georeferenced from Shaw 2010, Fig 3.8)

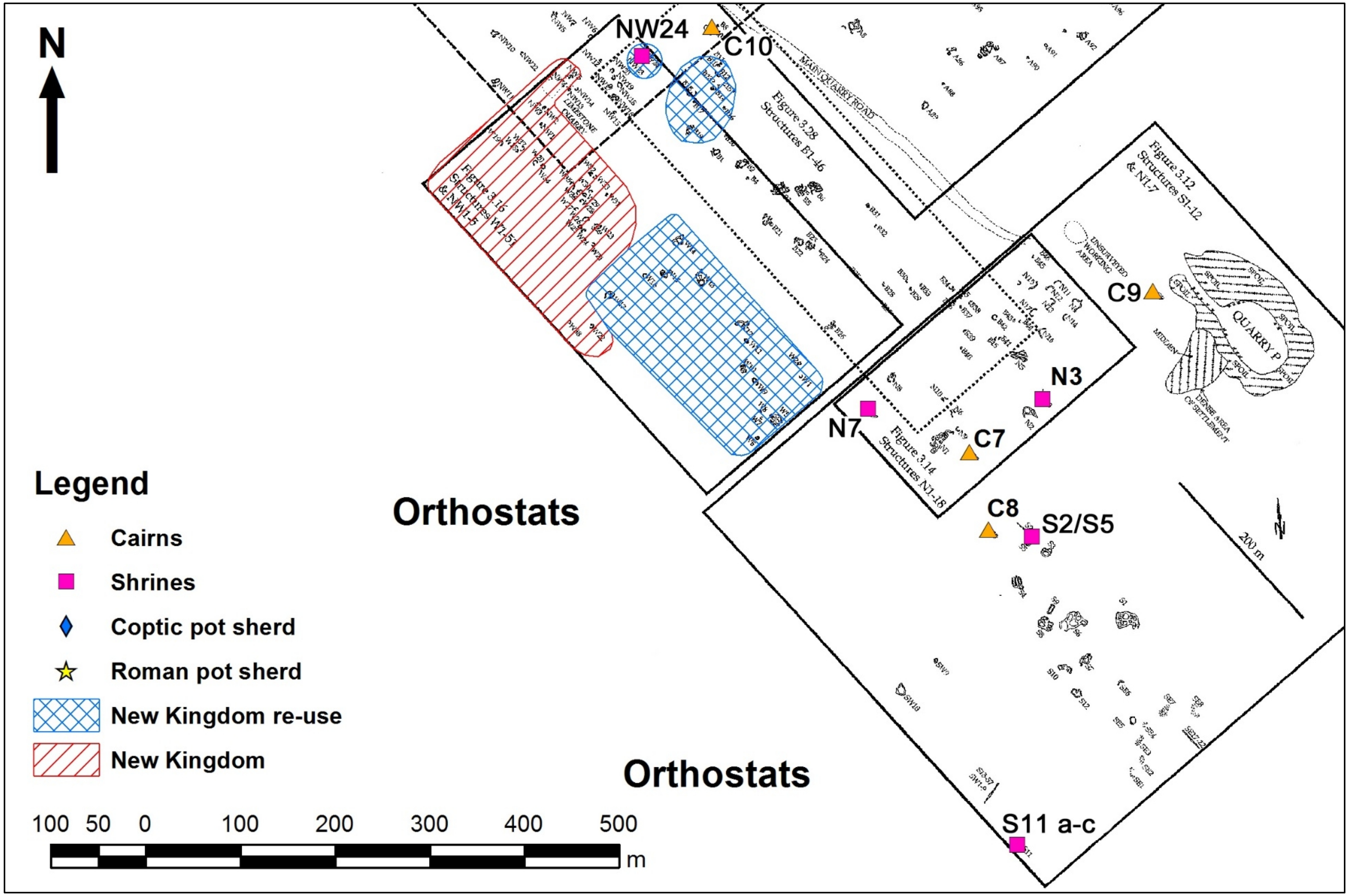


Fig 7.21: The southern section of the Old Kingdom settlement at Quarry P (Adapted and georeferenced from Shaw 2010, Fig 3.8)

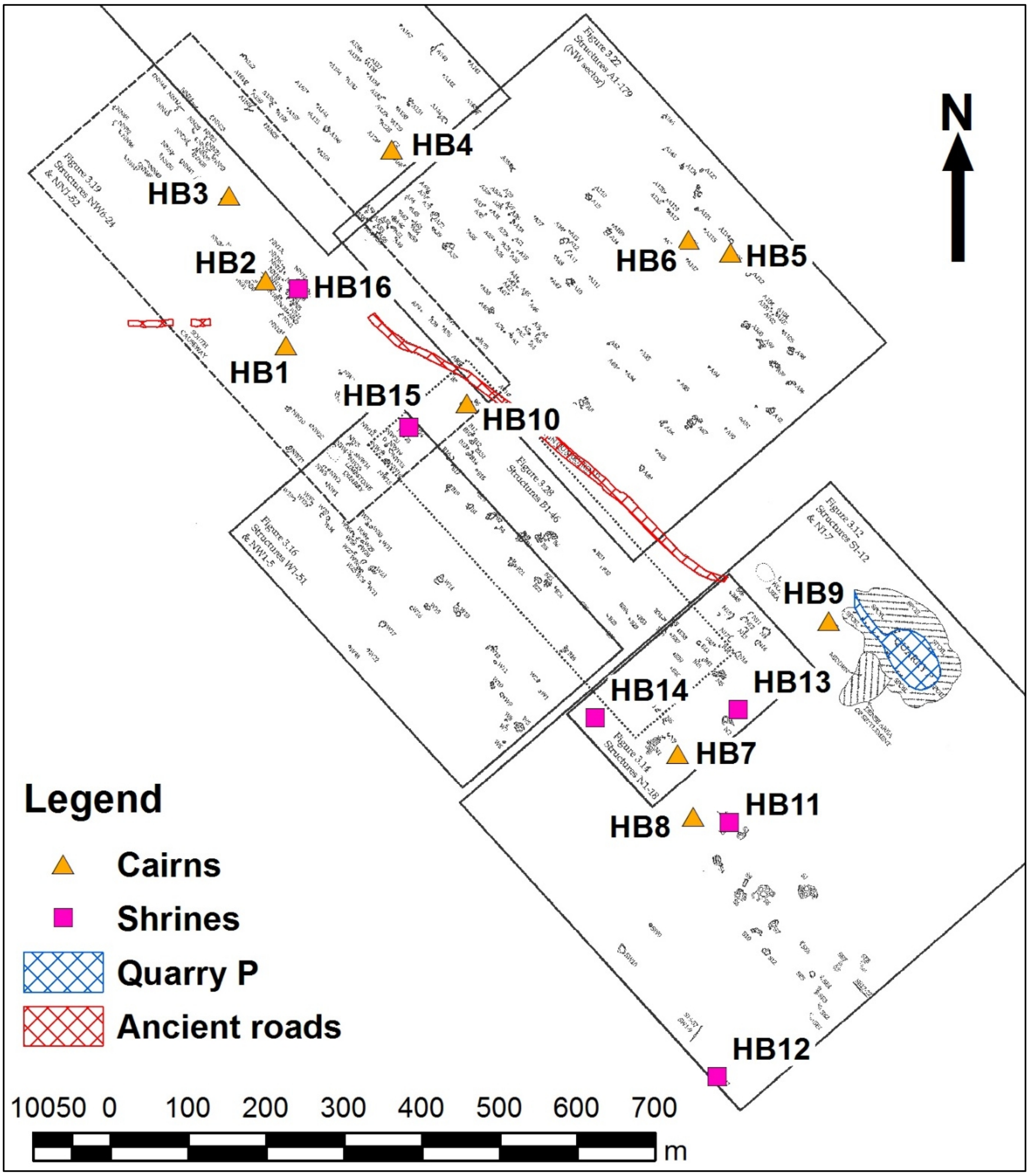


Fig 7.22: The Old Kingdom settlement along the approach to Quarry P showing the observer points for the visibility analysis (Adapted and georeferenced from Shaw 2010, Fig 3.8)

Table 7.3: Observer points HB1–16 for visibility analysis at Hatnub.

Observer point	Type	Designation	Notes (After Shaw 2010)
HB1	Cairn	C1	
HB2	Cairn	C2	
HB3	Cairn	C3	
HB4	Cairn	C4	
HB5	Cairn	C5	
HB6	Cairn	C6	
HB7	Cairn	C7	On the ‘peak’ associated with petroglyphs
HB8	Cairn	C8	At the opposite end of the ‘peak’ from C7.
HB9	Cairn	C9	Cairn beside Quarry P
HB10	Cairn	C10	Associated with an Old Kingdom windbreak.
HB11	Shrine	S2 and S5	Two shrines located close together near the ‘peak’.
HB12	Shrine	S11 a-c	Three shrines close together.
HB13	Shrine	N3	
HB14	Shrine	N7	Shrine of ‘dolmen’ construction.
HB15	Shrine	NW24	Near cairn 10, associated with NW23, an ‘administrative’ structure.
HB16	Shrine	NN9 and NN10	Two shrines close together, near cairn 2

Results

The individual projective and reflective viewsheds for each HB observer point are presented in Fig 7.23 – Fig 7.38. Table 7.4 details the size of the viewsheds in number of raster cells, area in km^2 and ranks the viewsheds from 1 to 16, where 1 is the largest and 16 the smallest.

Collectively the viewsheds for the archaeological features at Hatnub do not focus on any single part of the landscape, although some viewsheds are more restricted than others. The north-west quadrant is the least inter-visible with either the cairns or the shrines, but some viewsheds do include elements of it. The projective viewsheds are more likely to include a wider range of bearings, while the reflective viewsheds are dominated by specific directions.

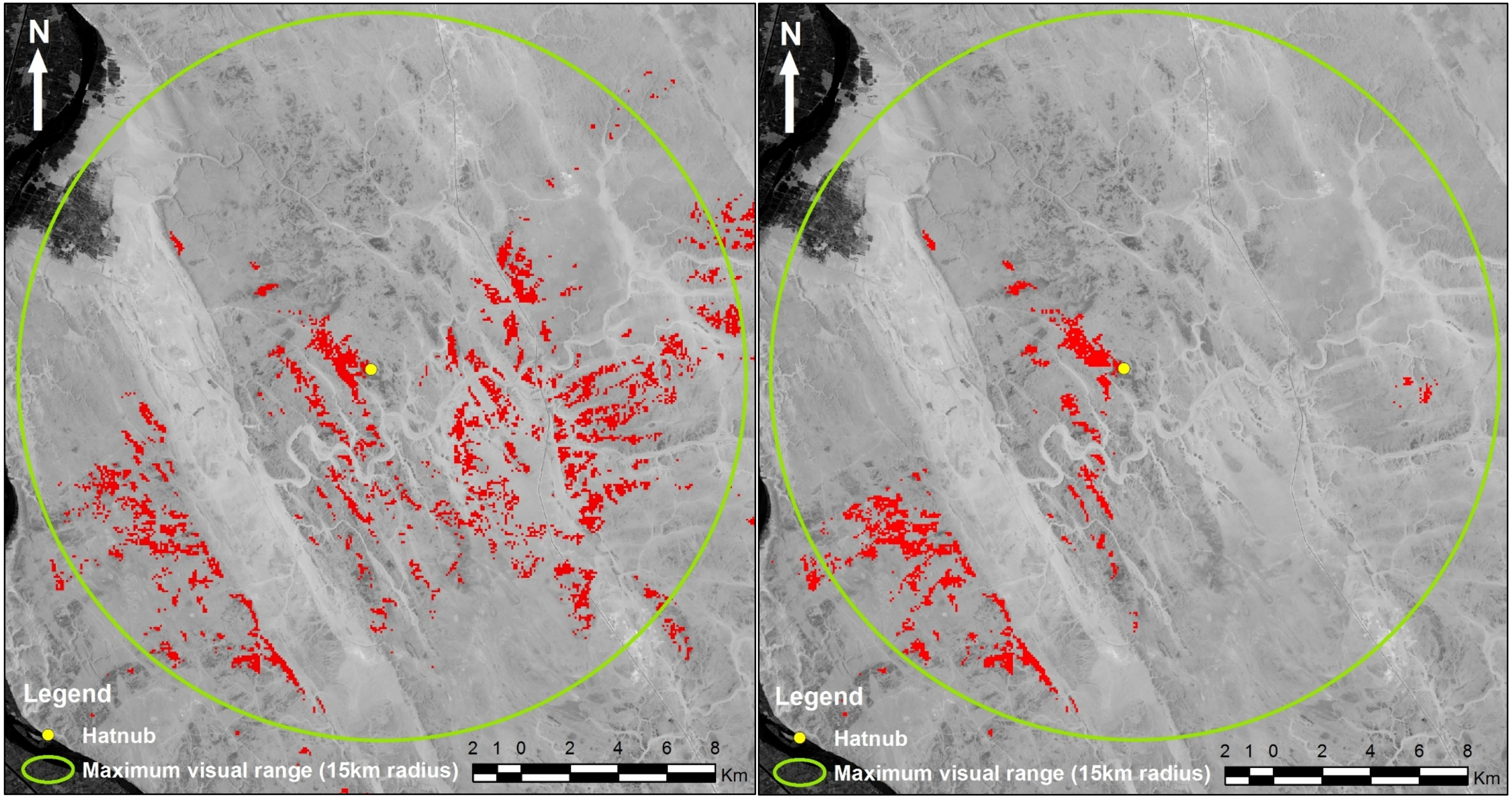


Fig 7.23: Viewsheds for HB1 a) Projective viewshed showing what was visible to HB1 (left) and b) Reflective viewshed showing where HB1 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

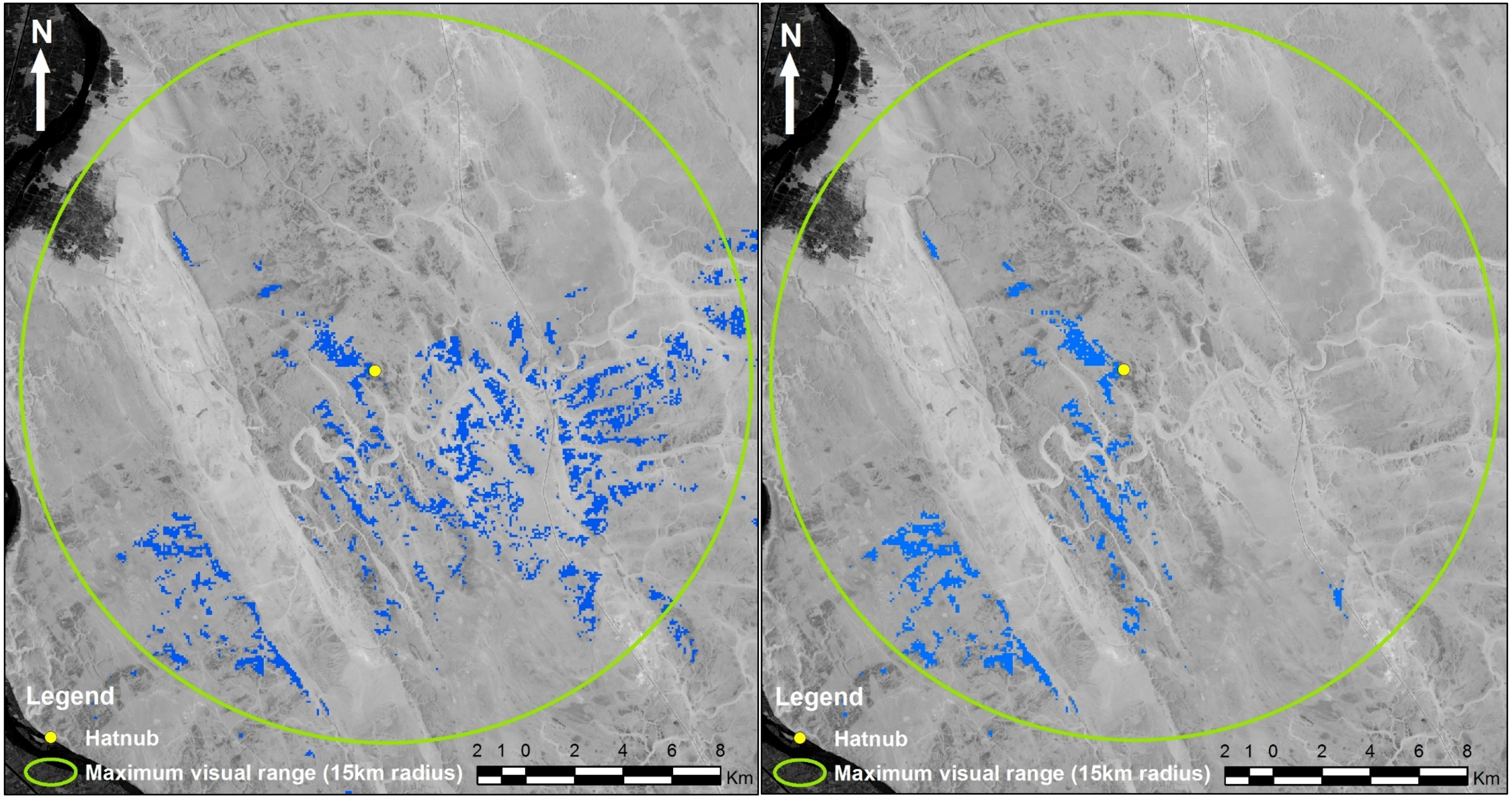


Fig 7.24: Viewsheds for HB2 a) Projective viewshed showing what was visible to HB2 (left) and b) Reflective viewshed showing where HB2 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

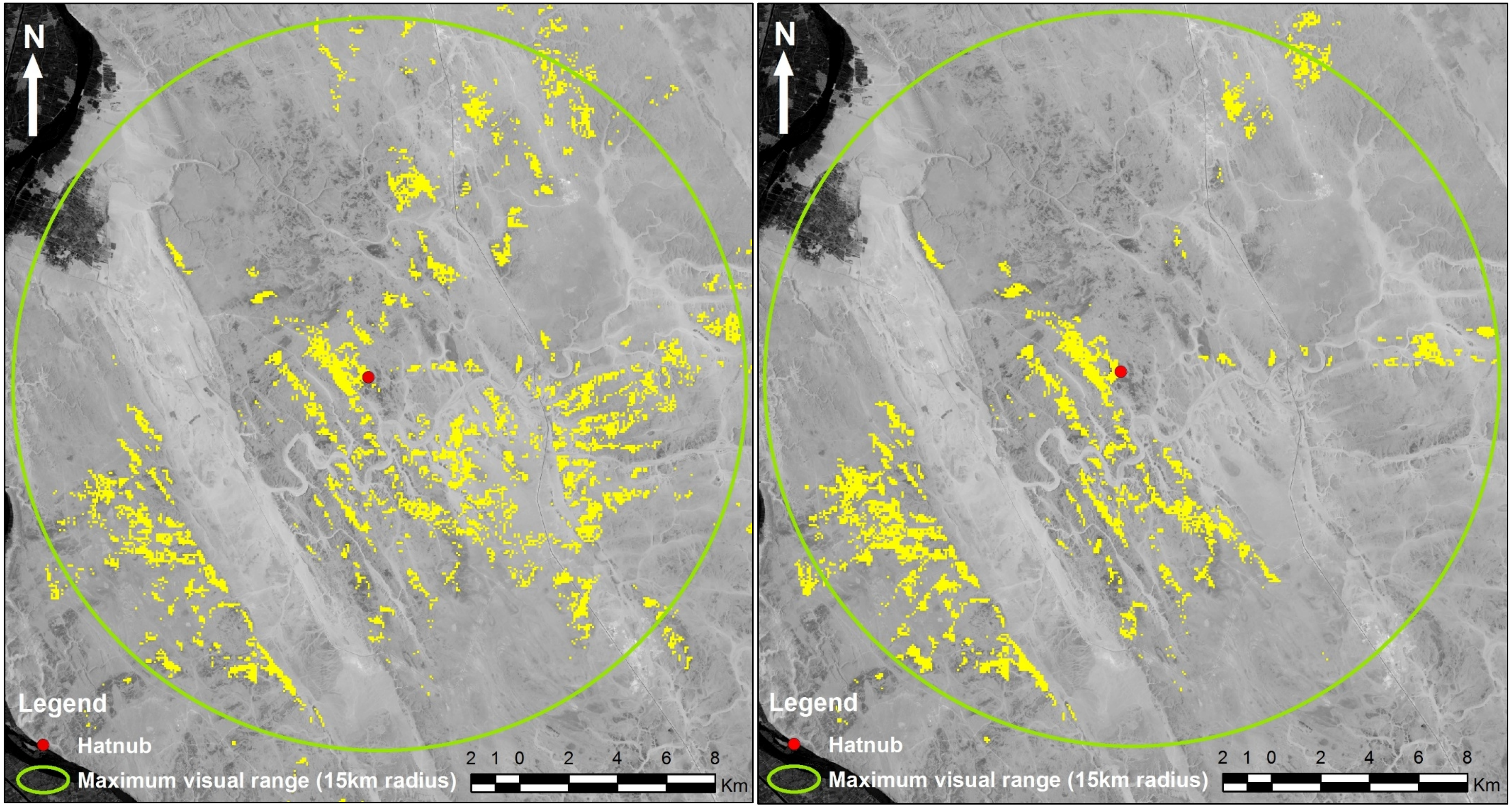


Fig 7.25: Viewsheds for HB3 a) Projective viewshed showing what was visible to HB3 (left) and b) Reflective viewshed showing where HB3 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

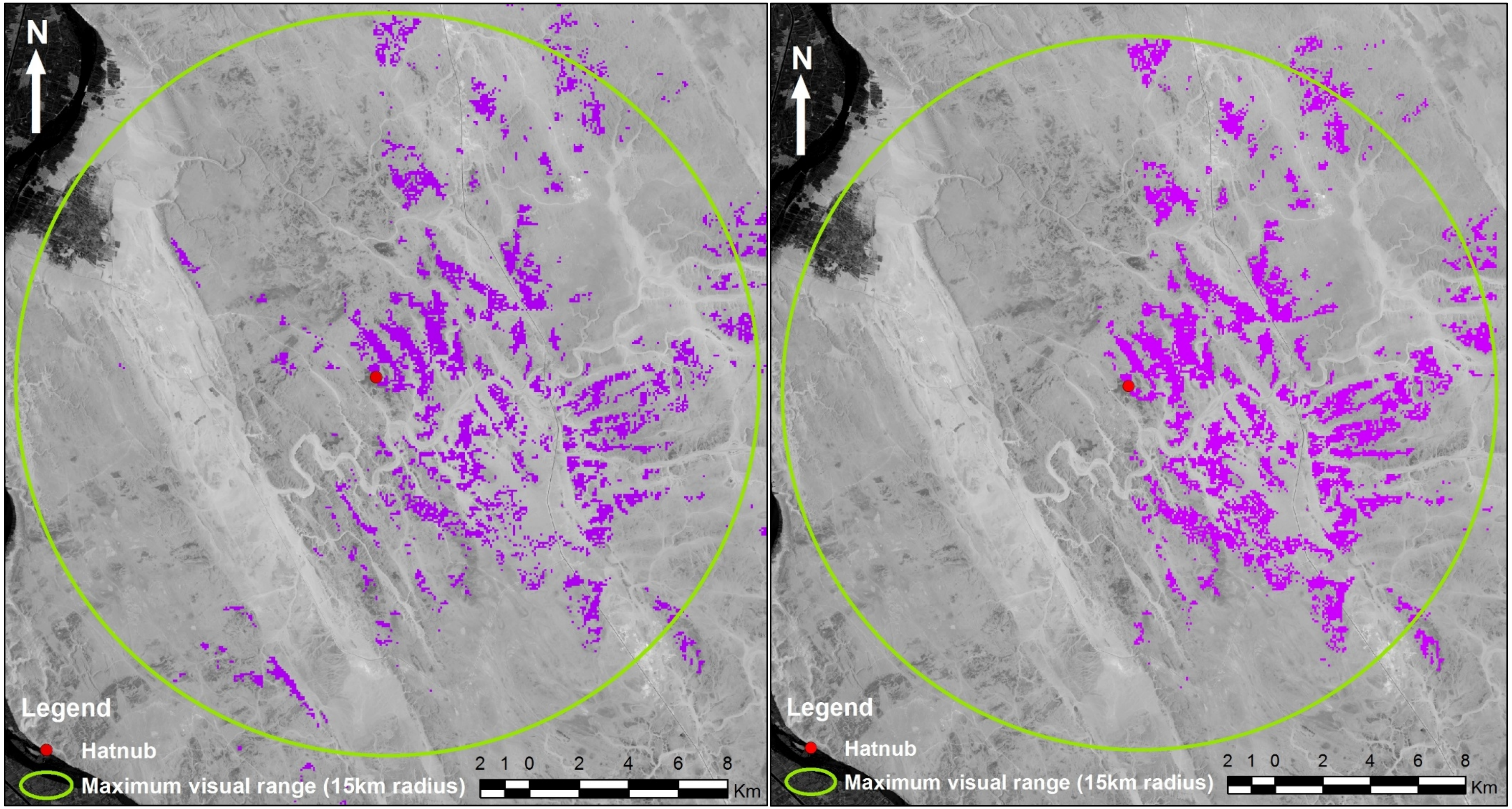


Fig 7.26: Viewsheds for HB4 a) Projective viewshed showing what was visible to HB4 (left) and b) Reflective viewshed showing where HB4 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

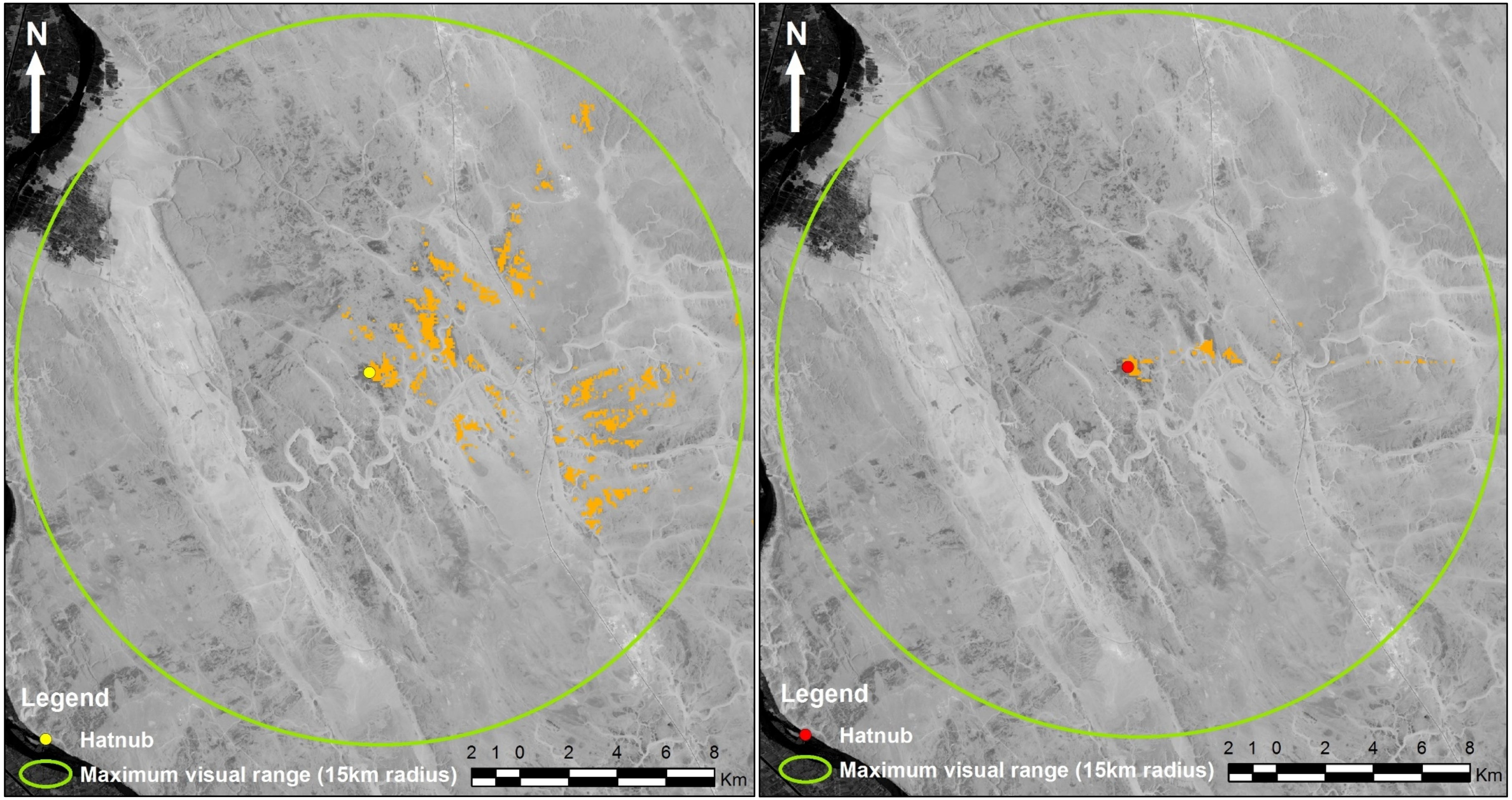
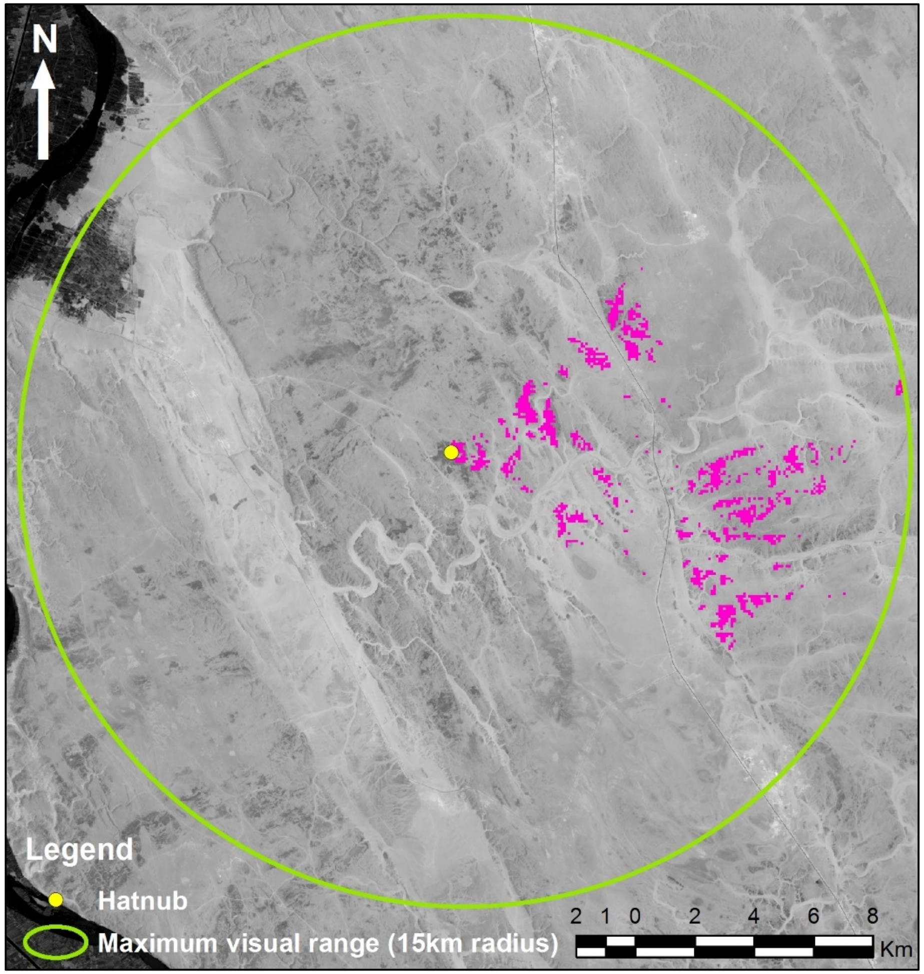


Fig 7.27: Viewsheds for HB5 a) Projective viewshed showing what was visible to HB5 (left) and b) Reflective viewshed showing where HB5 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).



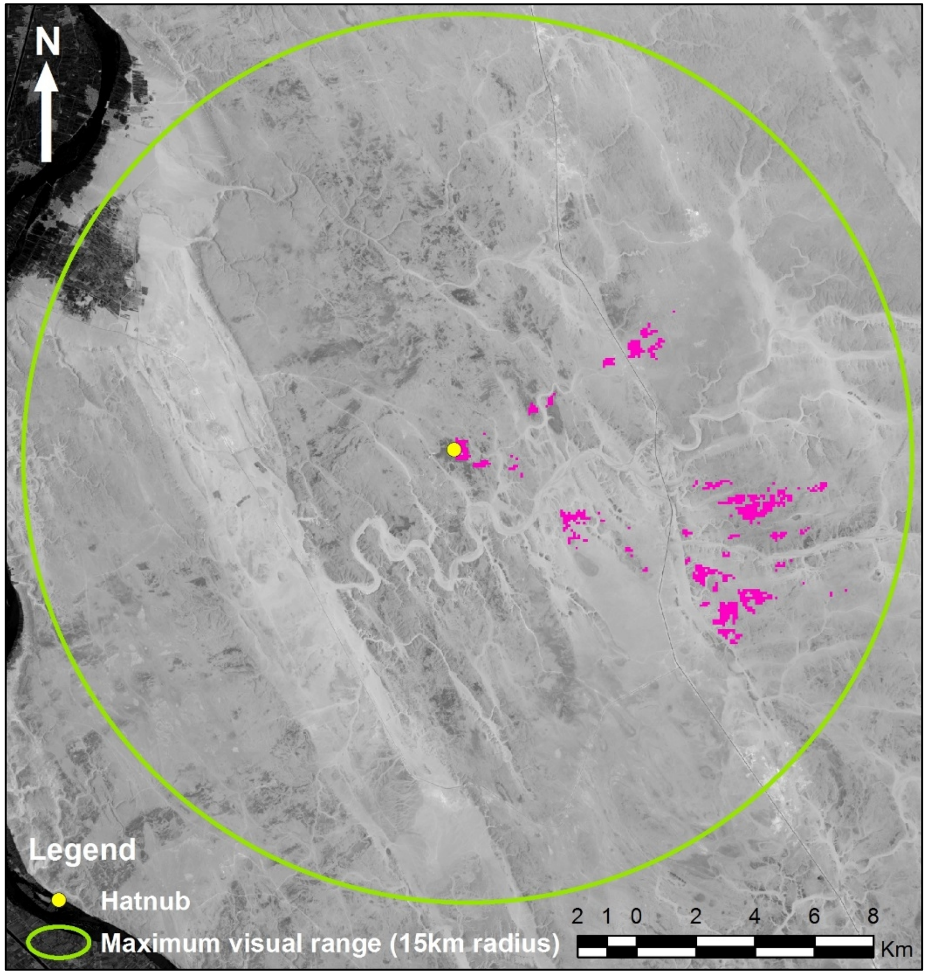


Fig 7.28: Viewsheds for HB6 a) Projective viewshed showing what was visible to HB6 (left) and b) Reflective viewshed showing where HB6 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

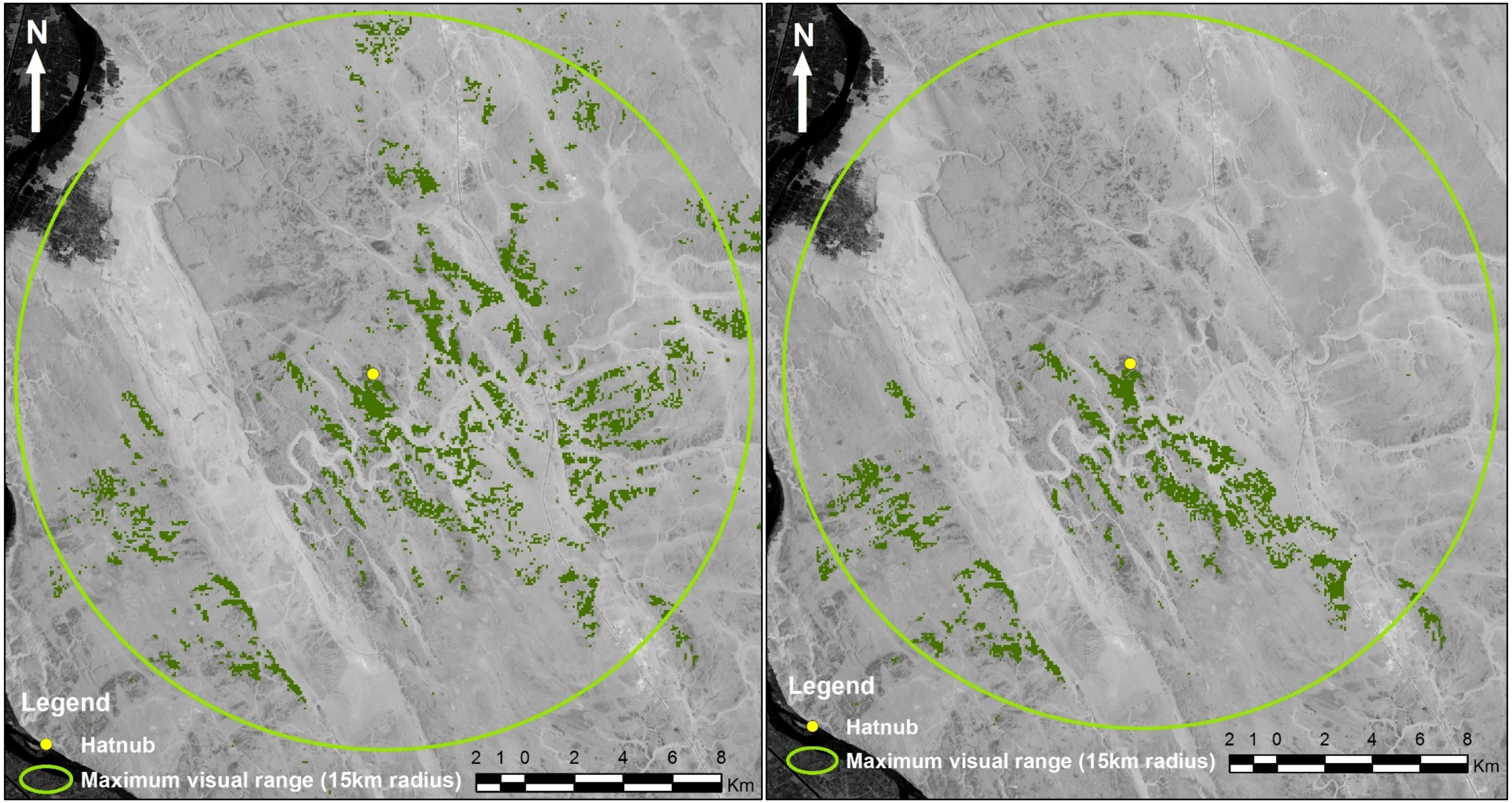


Fig 7.29: Viewsheds for HB7 a) Projective viewshed showing what was visible to HB7 (left) and b) Reflective viewshed showing where HB7 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

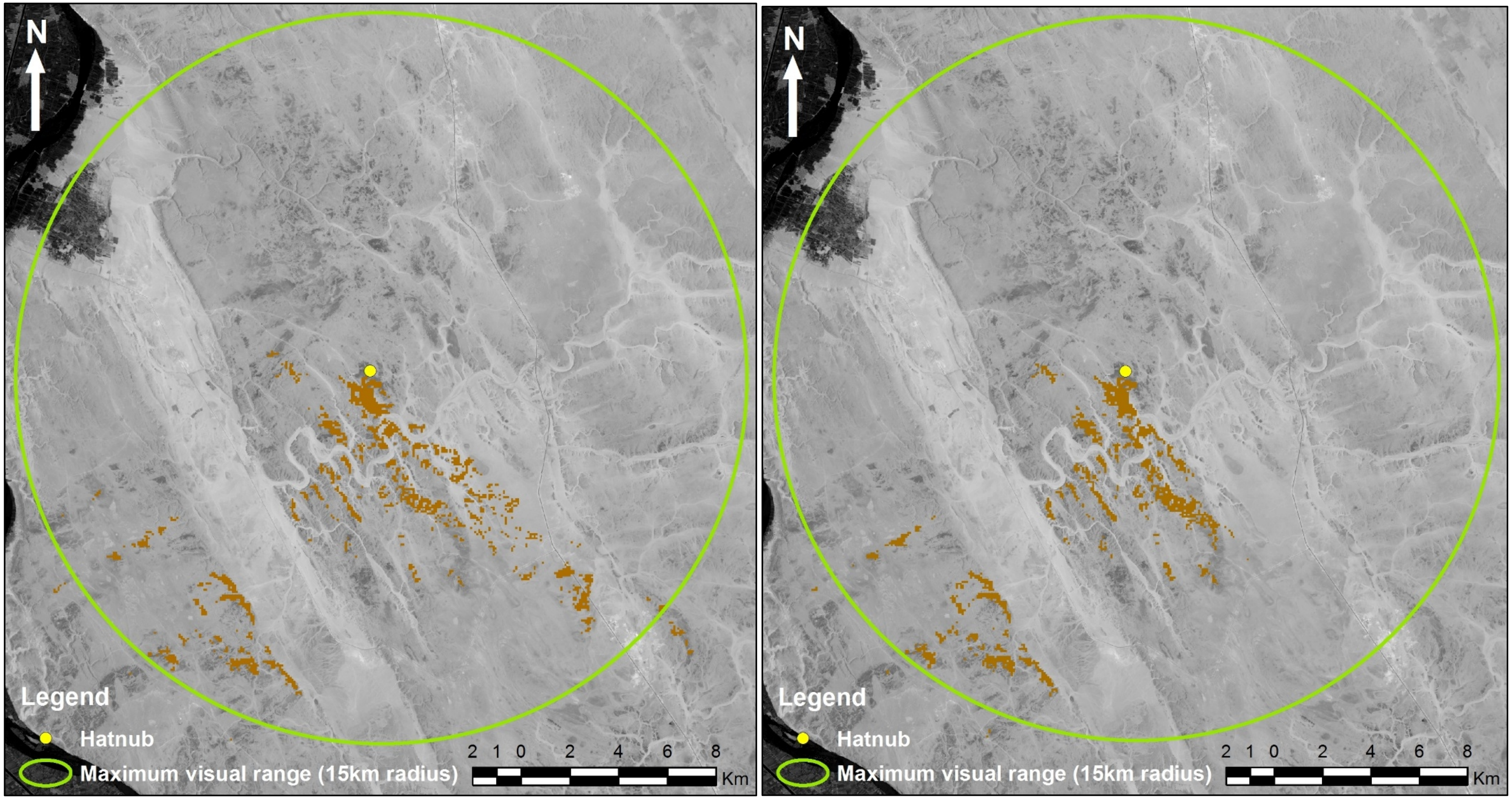


Fig 7.30: Viewsheds for HB8 a) Projective viewshed showing what was visible to HB8 (left) and b) Reflective viewshed showing where HB8 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

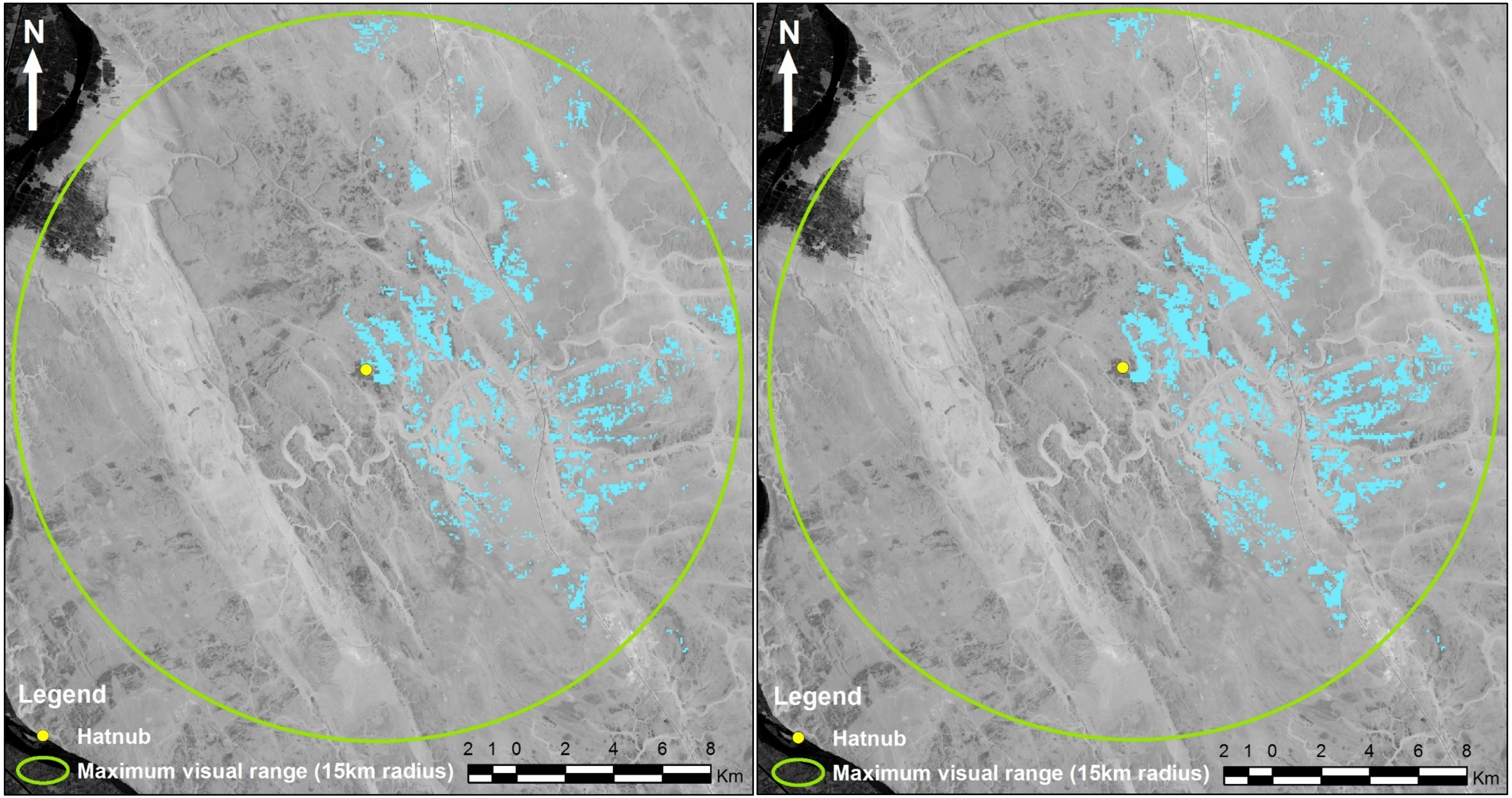


Fig 7.31: Viewsheds for HB9 a) Projective viewshed showing what was visible to HB9 (left) and b) Reflective viewshed showing where HB9 was visible (right), overlying Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 from 2013 (Landsat data from the USGS).

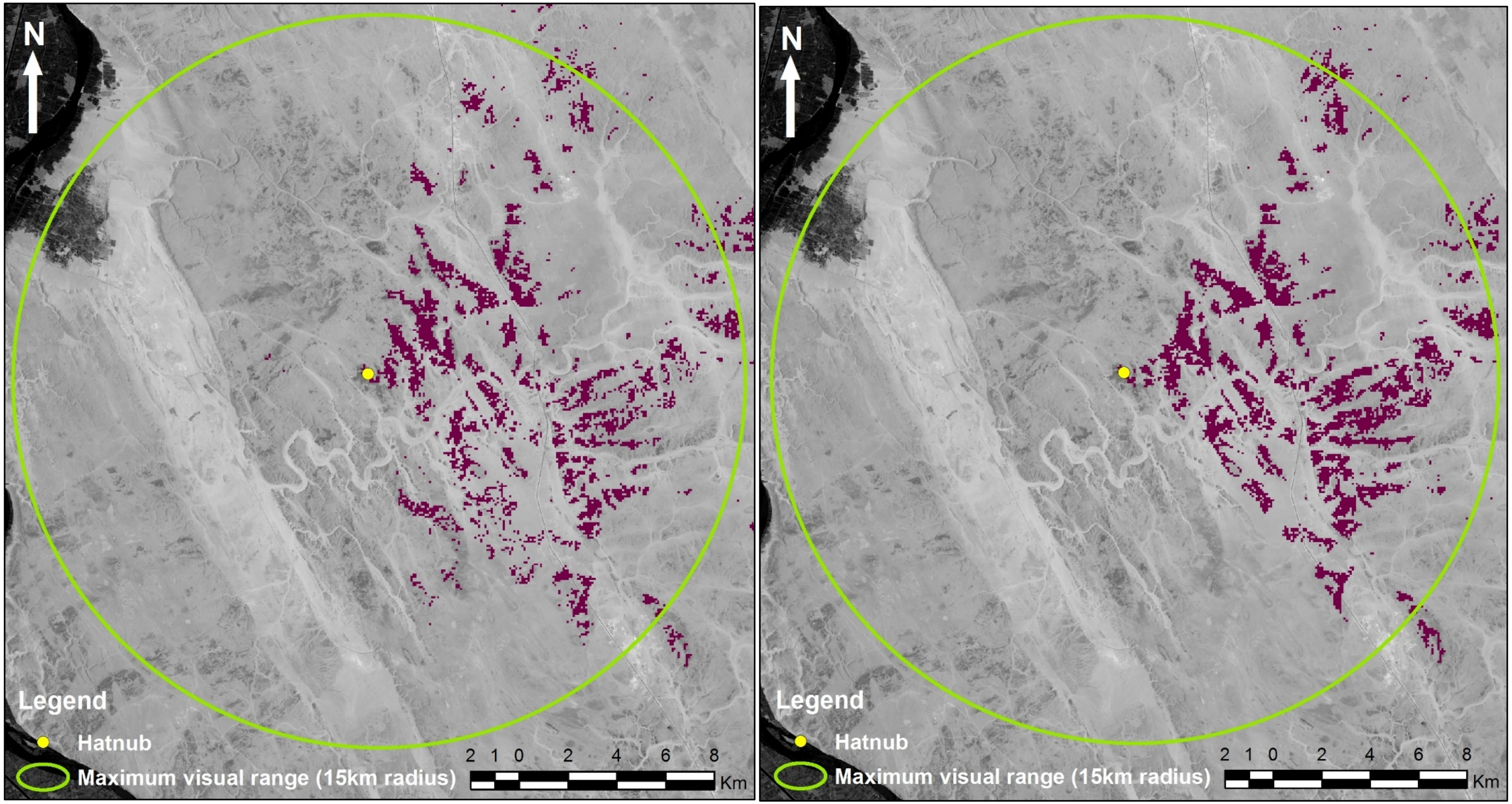


Fig 7.32: Viewsheds for HB10 a) Projective viewshed showing what was visible to HB10 (left) and b) Reflective viewshed showing where HB10 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).

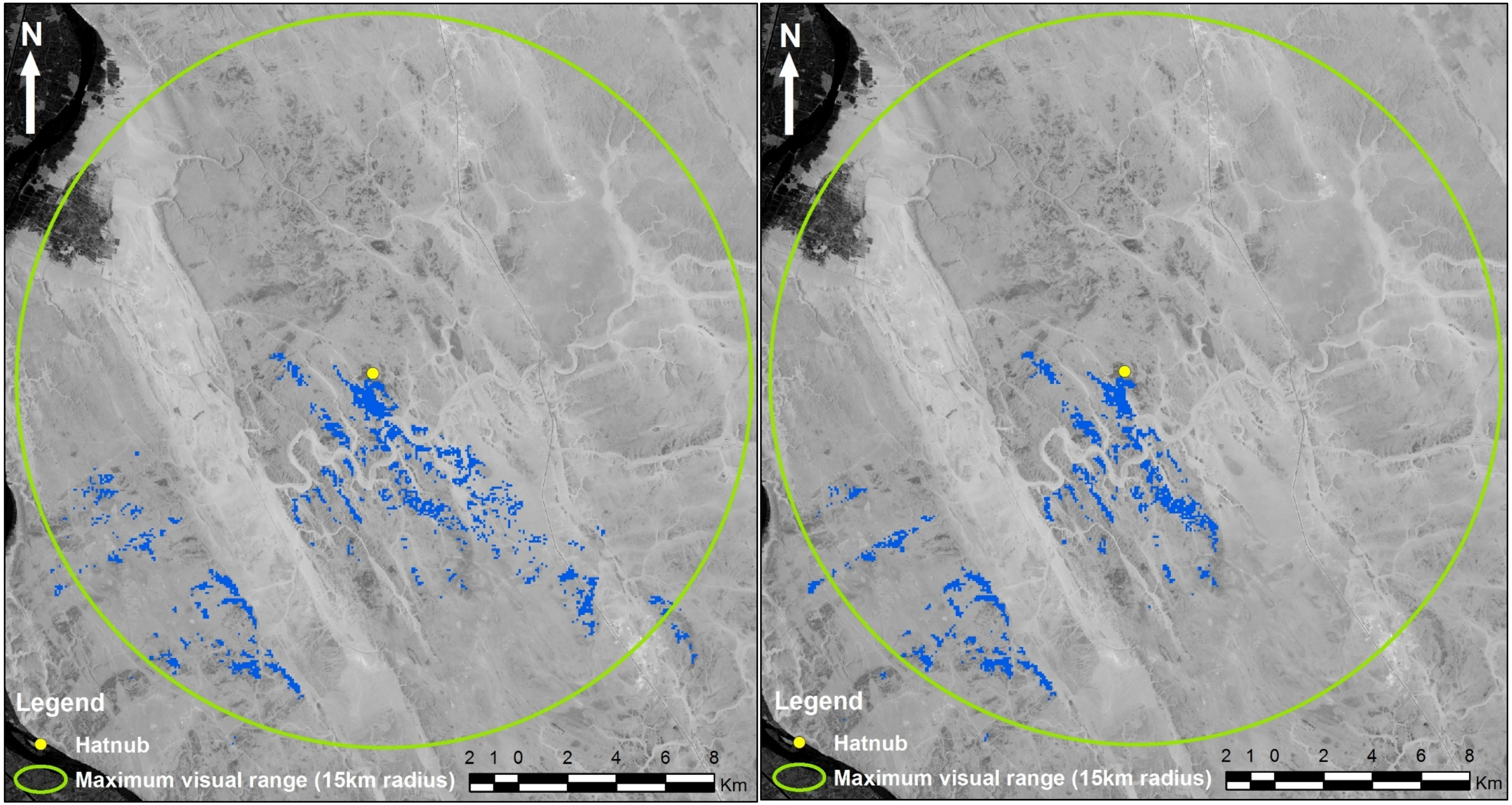


Fig 7.33: Viewsheds for HB11 a) Projective viewshed showing what was visible to HB11 (left) and b) Reflective viewshed showing where HB11 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).

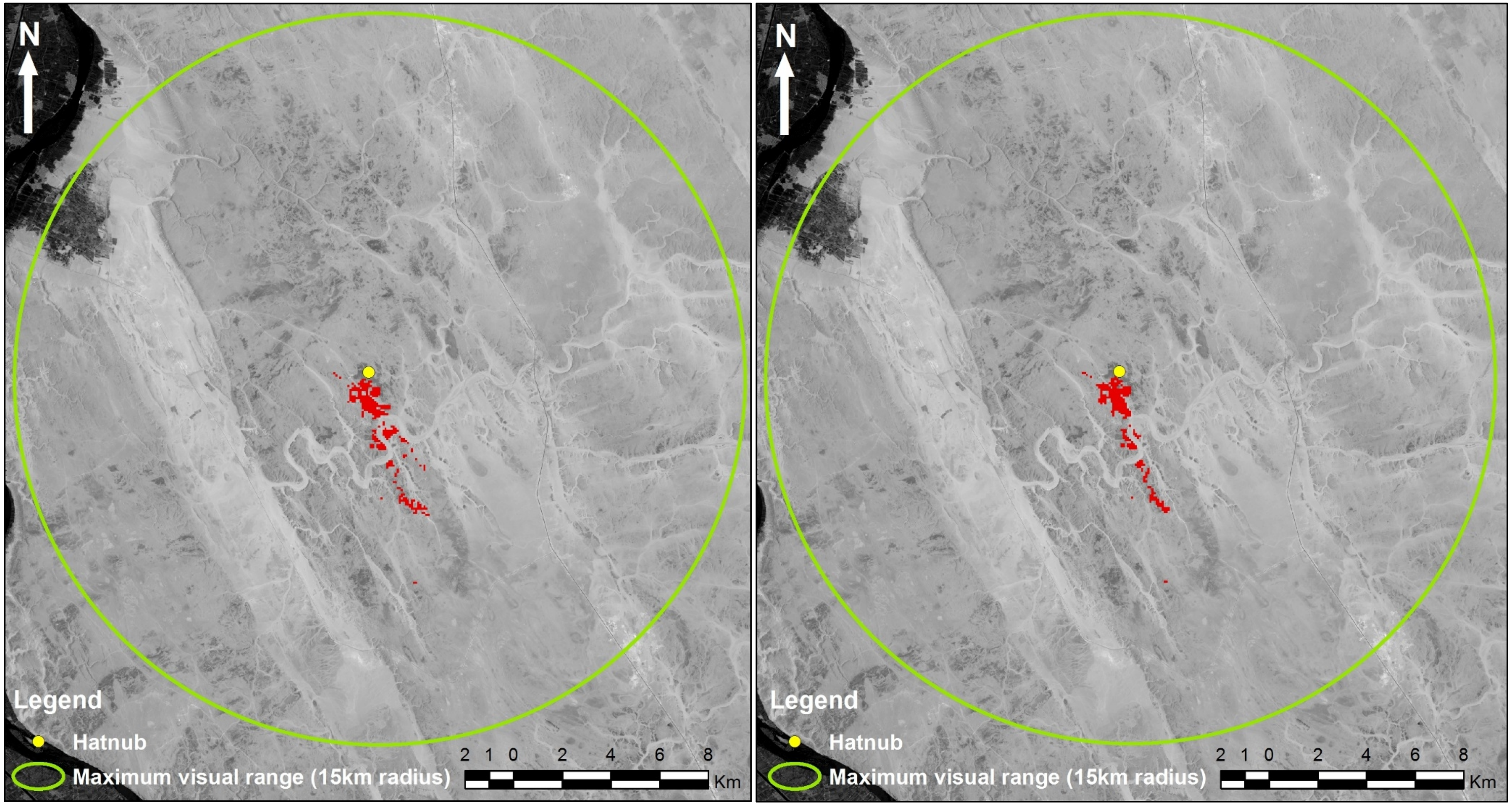


Fig 7.34: Viewsheds for HB12 a) Projective viewshed showing what was visible to HB12 (left) and b) Reflective viewshed showing where HB12 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).

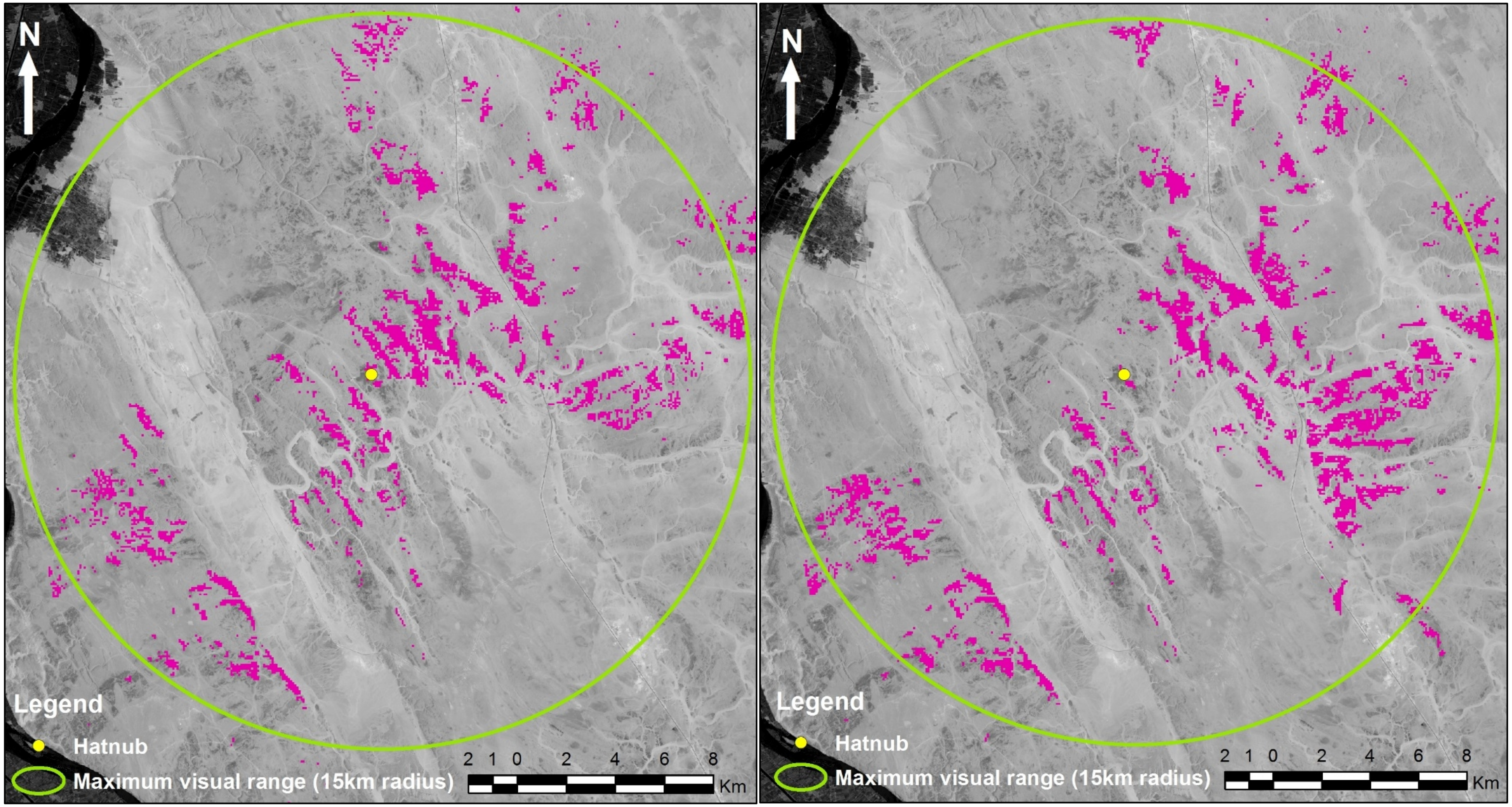
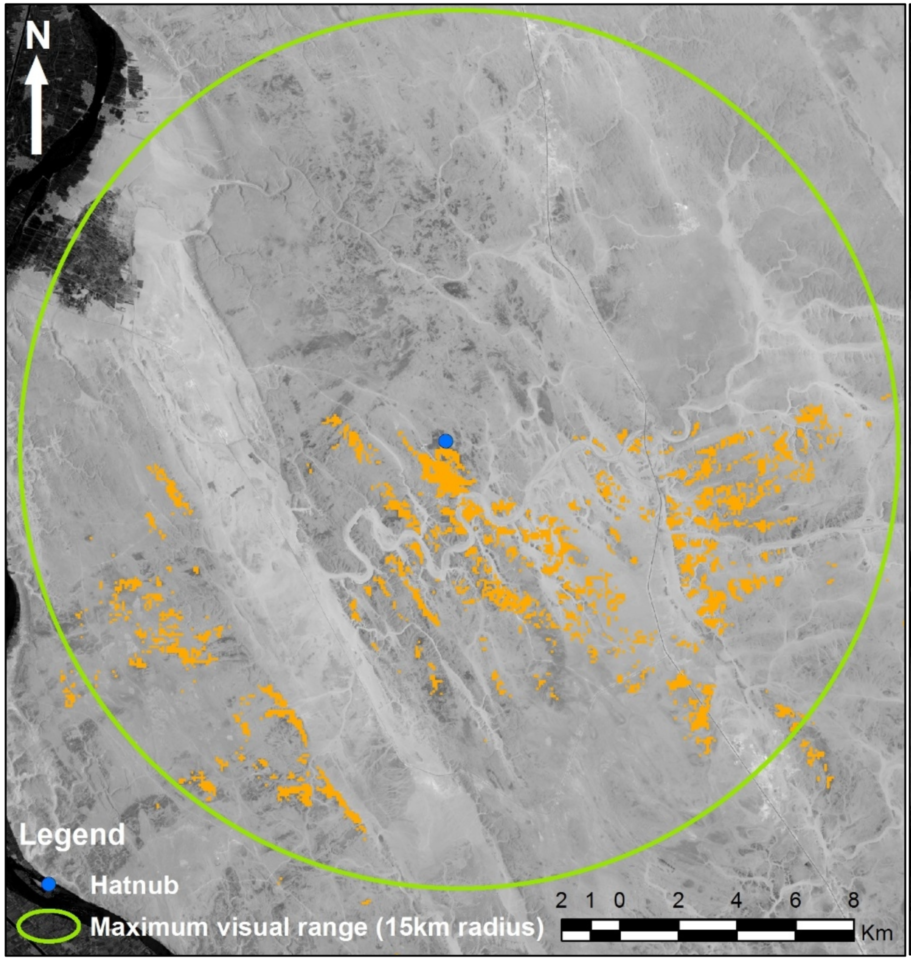


Fig 7.35: Viewsheds for HB13 a) Projective viewshed showing what was visible to HB13 (left) and b) Reflective viewshed showing where HB13 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).



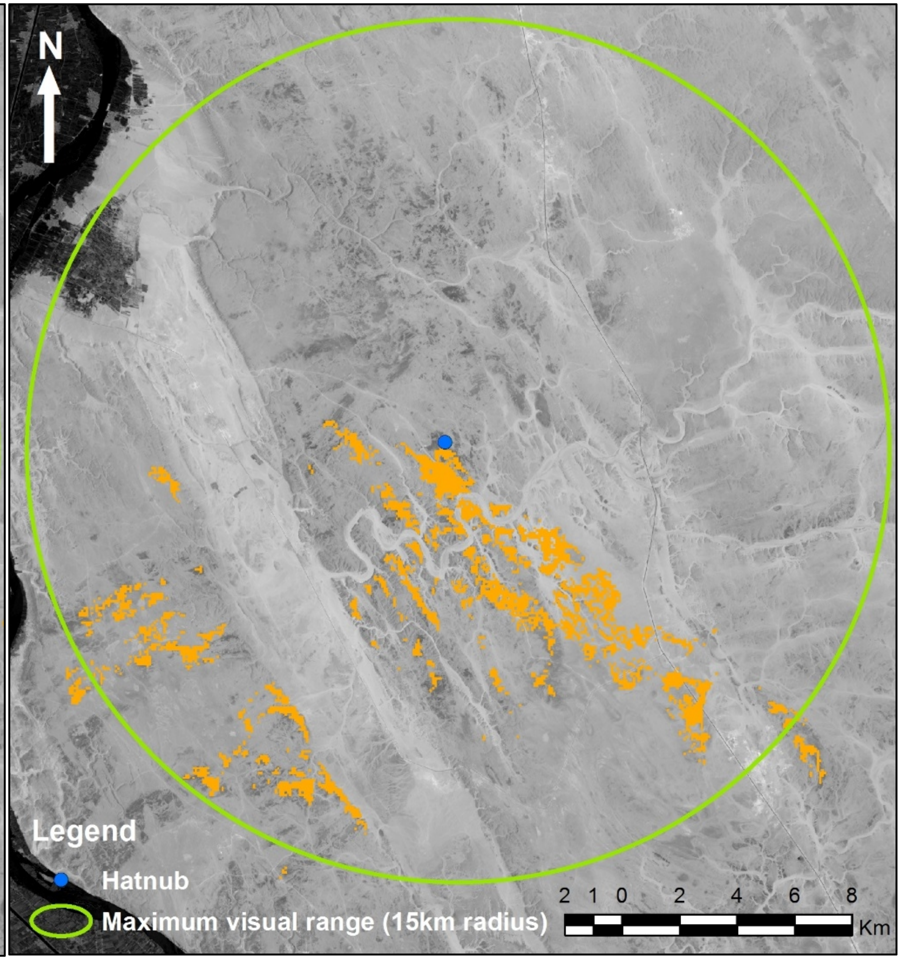


Fig 7.36: Viewsheds for HB14 a) Projective viewshed showing what was visible to HB14 (left) and b) Reflective viewshed showing where HB14 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).

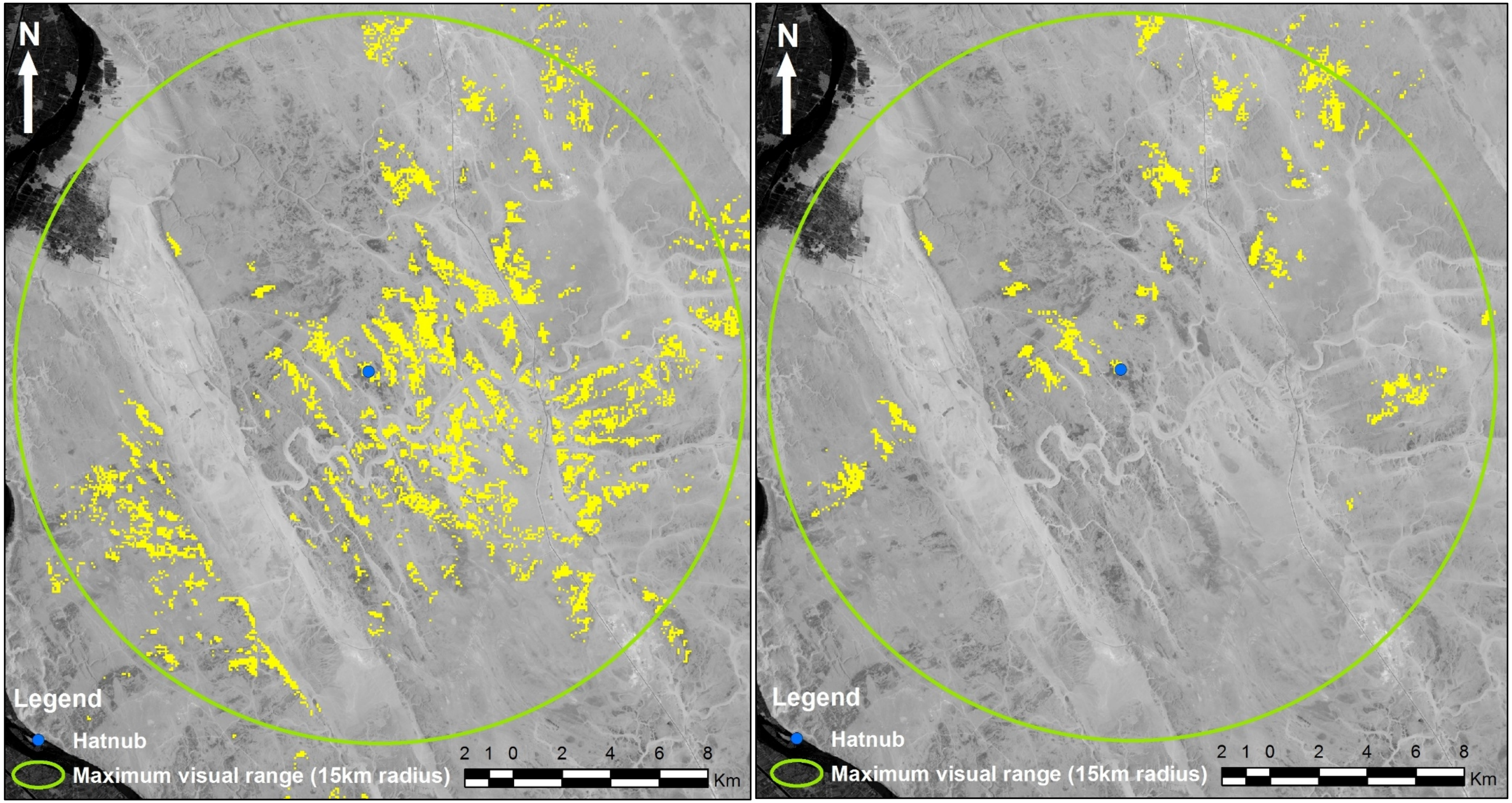


Fig 7.37: Viewsheds for HB15 a) Projective viewshed showing what was visible to HB15 (left) and b) Reflective viewshed showing where HB15 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).

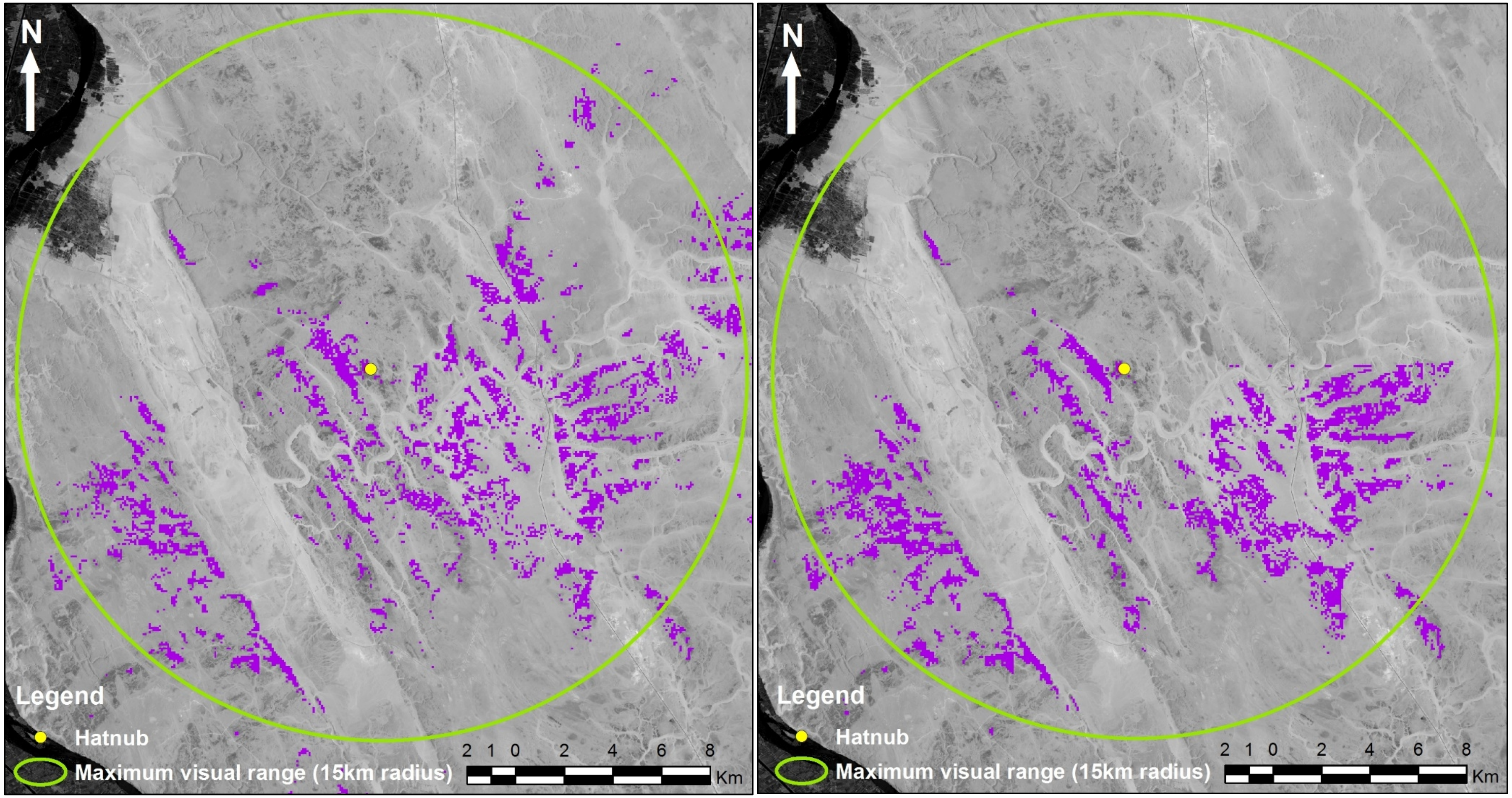


Fig 7.38: Viewsheds for HB16 a) Projective viewshed showing what was visible to HB16 (left) and b) Reflective viewshed showing where HB16 was visible (right), shown overlying 2013 Landsat 8, Band 8 15m resolution image LC81760412013183LGN00 (Landsat data from the USGS).

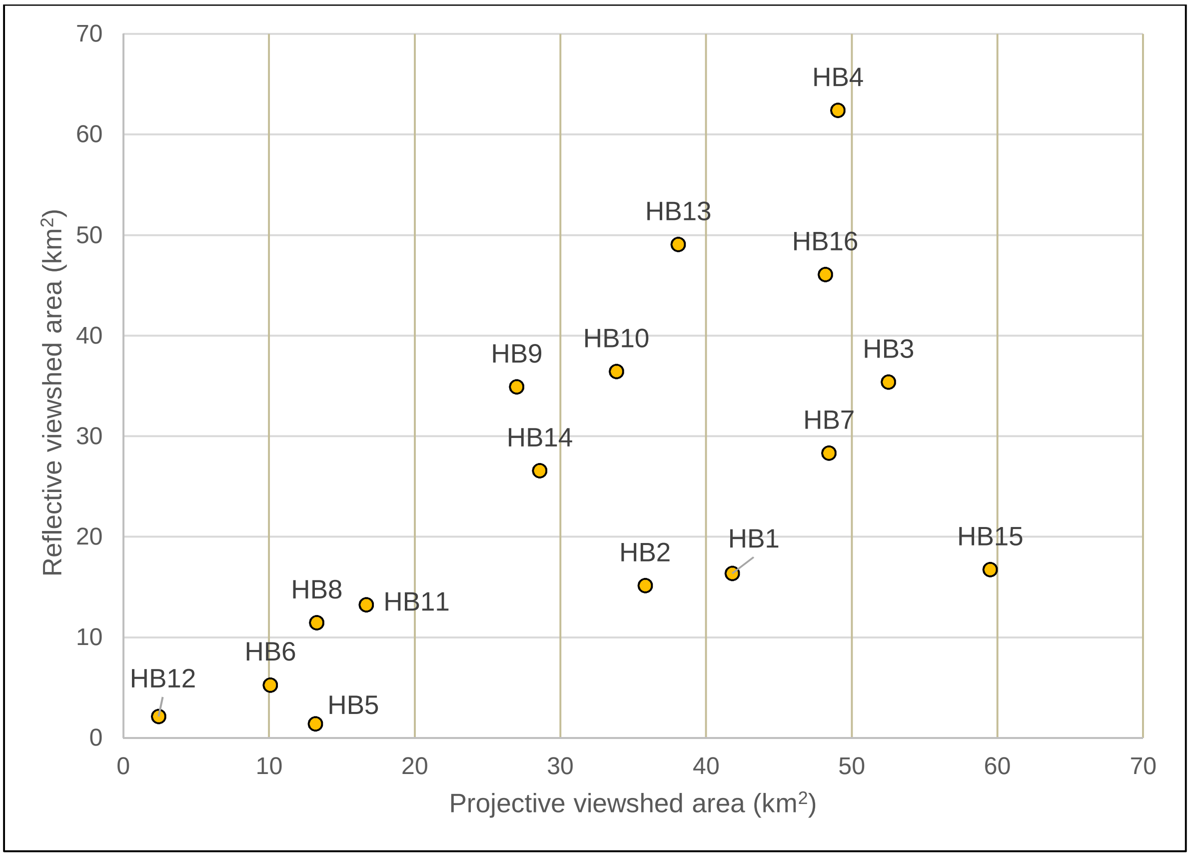
Table 7.4: Sizes of projective and reflective viewsheds of HB1–HB16 at Hatnub.

Observer point	Feature	Projective			Reflective		
		Raster cells		Rank	Raster cells		Rank
		Number	Area (km^2)		Number	Area (km^2)	
HB1	C1	5590	41.79	6	2189	16.36	10
HB2	C2	4790	35.81	8	2027	15.15	11
HB3	C3	7025	52.51	2	4733	35.38	5
HB4	C4	6561	49.05	3	8348	62.40	1
HB5	C5	1763	13.18	14	186	1.39	16
HB6	C6	1350	10.09	15	703	5.26	14
HB7	C7	6479	48.43	4	3789	28.32	7
HB8	C8	1775	13.27	13	1531	11.44	13
HB9	C9	3610	26.99	11	4668	34.90	6
HB10	C10	4527	33.84	9	4875	36.44	4
HB11	S2 & S5	2230	16.67	12	1772	13.25	12
HB12	S11 a-c	322	2.41	16	285	2.13	15
HB13	N3	5095	38.09	7	6564	49.07	2
HB14	N7	3822	28.57	10	3554	26.57	8
HB15	NW24	7960	59.50	1	2240	16.74	9
HB16	NN9 & NN10	6445	48.18	5	6163	46.07	3

Table 7.4 shows that viewshed size is quite variable from 1.39km^2 to 62.40km^2. Mean projective viewshed size is 32.40km^2 and mean reflective viewshed size is 25.05km^2. There is no correlation between the type of feature and the size of the viewshed. Both the group of cairns (HB1–HB10) and the group of shrines (HB11–HB16) include very large and very small viewsheds. There is also quite a lot of variation between the sizes of the projective and reflective viewsheds, although there is a general positive correlation between projective and reflective viewshed size with larger projective viewsheds tending to predict larger reflective viewsheds. This is most clearly visible in Chart 7.2, which shows the areas of the projective and reflective viewsheds plotted against each other for each HB observer point.

Chart 7.2 clearly shows that there is a distinctive group of cairns and shrines with generally small projective and reflective viewsheds. Three cairns C5, C6 and C8 (HB5, HB6 and HB8) and three shrines S2 and S5 and S11a-c (HB11 and HB12) all have viewsheds of less than 20km^2 and are ranked lower than 10th of all the observer points. Their small size also affects the areas visible in the viewsheds, which are typically restricted to relatively small segments of the landscape (Fig 7.27, Fig 7.28, Fig7.35, Fig 7.33 and Fig 7.34).

Chart 7.2: The viewsheds for HB1–HB16 plotted to show the correlation in size between the projective and reflective viewsheds. Made with data from Table 7.4.



Apart from this small group and unlike the features at Serabit el-Khadim and Stelae Ridge, the Hatnub cairns and shrines are much harder to divide into groups based upon their visibility. It is possible that cairns C3, C4, C7 and perhaps C10 (HB3, HB4, HB7 and HB10) form a group of cairns with larger viewsheds (Fig 7.25, Fig 7.26, Fig 7.29 and Fig 7.32). Shrines N3, NW24 and NN9 and NN10 (HB13, HB15 and HB16) have generally larger viewsheds than the other shrines (Fig 7.35, Fig 7.37 and Fig 7.38), but it is difficult to draw definite conclusions about this 'group' when the viewsheds of the features within it are so varied and it includes structures like NW24, which has the largest projective viewshed coupled with a very small reflective viewshed.

Purpose and visibility: Shrines

Given their appearance and construction, it is likely that the 'shrines' had some ritual function. While this interpretation is largely due to the absence of any apparent practical function it is reasonable. In general they are small domed or roofed structures, with interior spaces too small for a human, approached by stone lined tracks. NW24 has an additional orthostat located in front of the domed structure (Shaw 2010, 67), and N7 and S5 do not have a stone-lined track. Fraser's (1894) suggestion that they are ovens was disproved by the lack of burning around them (Shaw 2010, 103). Many of these structures are located close to nearby cairns (Shaw, 2010, 103–105).

The shrines S2 and S5 (HB11), S11a-c (HB12), N3 (HB13), N7 (HB14), NW24 (HB15) and NN9 and NN10 (HB16) have very variably sized viewsheds, ranging from 2.13km^2 to 59.50km^2. Those viewsheds are also very varied in the areas they include (Fig 7.33, Fig 7.34, Fig 7.35, Fig 7.36, Fig 7.37 and Fig 7.38), and there is no consistent focus upon any one part of the landscape.

Shrine NW24 (HB15) had the largest projective viewshed of all the structures, but its reflective viewshed was ranked 9th. The very large projective viewshed and the views towards both the north and the south shown in Fig 7.37a, suggest that NW24 was located on the crest of the ridge, where an observer would have a very good view in all directions.[359] The reflective viewshed was small because this area of the Hatnub settlement is not overlooked by higher ground and there are limited areas where it is possible to see ground level at NW24. This could explain the presence of a 0.28m high pointed stone erected as part of NW24 (Shaw 2010, 51), which would make the position more visible than has been accounted for in the visibility analysis, particularly if it stood out against the horizon.[360]

The prominent location of NW24 might be associated with the significance of the adjacent structure NW23, which was interpreted as an important administrative locus and depot for travertine in both the Old and New Kingdoms (Shaw 2010, 67–72). Since NW23 shares the same visual properties as NW24, it is likely that those creating and using NW23 as a depot for travertine would have wanted a good view of the quarrying area, in order to maintain control and be prepared for the movement of travertine blocks to and from the depot. It is not possible to tell whether the location was chosen for NW23 for practical purposes, and NW24 was simply constructed next to it, or whether visibility was also significant for NW24. Either way, as the 'shrine' adjacent to the depot and administrative locus, NW24 was perhaps of greater significance than the others.

The proximity of most of the shrines to nearby cairns has also been interpreted as evidence of a ritual relationship between these cairns and the shrines near them. A relationship has

---

[359] Identification of the ridge running through the Hatnub settlement later confirmed that NW24 is located in a commanding position right on the crest, as defined by the SRTM cell values. This is shown on Fig 7.39 on page 405.

[360] Riemer (2013) describes how upright stones used as landmarks on the Abu Ballas trail were set up to be visible against the horizon and the use of similar structures was also noted at Stelae Ridge in Chapter 3, section 3.7.3, especially Fig 3.24.

been posited between cairns C7 and C8 and shrines S2, S5, N3 and N7; between cairn C2 and shrines NN9 and NN10; and between cairn C10 and shrine NW24. (Shaw 2010, 99–105). Although shrine S11a-c (HB12) is not located close to any cairn in the published plans, Shaw (2010, 103–104) reveals that it was placed ‘at the foot of a knoll surmounted by a large cairn’. It is likely that there is some relationship between some of the cairns and nearby shrines, but it is not possible to determine whether this simply reflects a relationship between the cairns and the surrounding archaeological features generally or if there is a more specific relationship between the cairns and shrines. Visibility analysis of the area of settlement using a much higher resolution DEM than the SRTM might reveal more details.

Purpose and visibility: Cairns

Like the shrines the cairns’ viewsheds vary widely in both size, from 1.39km^2 to 62.40km^2, and in the areas of the landscape inter-visible with them (Fig 7.23 – Fig 7.32). However, the specific relationships between each cairn and the areas inter-visible with it provide more insight.

Taken as a group cairns C1–C10 (HB1–HB10) are inter-visible with a wide area of the landscape from most directions. It is likely that those approaching the site would have had a view of at least one cairn as they drew closer to it. This is particularly significant because of the nature of the reflective viewsheds of the cairns. Irrespective of viewshed size, the reflective viewsheds are quite restricted in terms of the direction from which each individual cairn could be seen. Cairns C1, C2, C3, C7 and C8, represented by HB1, HB2, HB3, HB7 and HB8, are predominantly visible from the south and west (Fig 7.23 – Fig 7.25 and Fig 7.29 – Fig 7.30). Cairns C4, C5, C6, C9 and C10 (HB4, HB5, HB6, HB9 and HB10) are predominantly visible from the north and east (Fig 7.26–Fig 7.28 and Fig 7.31–Fig 7.32).

This division reflects the position of the two groups of cairns on either side of the ridge, which is aligned from north-west to south-east (Fig 7.39). Comparison with the SRTM cell values shows that none of the cairns are located on the crest of the ridge, and therefore they are less visible than they could have been. In reality the height of the cairns would have made them more visible than the 0m target height used in the reflective visibility analysis, but they would still have been more prominent if they had been located along the crest of the ridge, rather than slightly off it. This suggests that creating cairns in the most prominent location, along the crest of the ridge, was not a primary consideration in their construction and that their actual locations were sufficiently visible for the purposes of the cairn-builders.

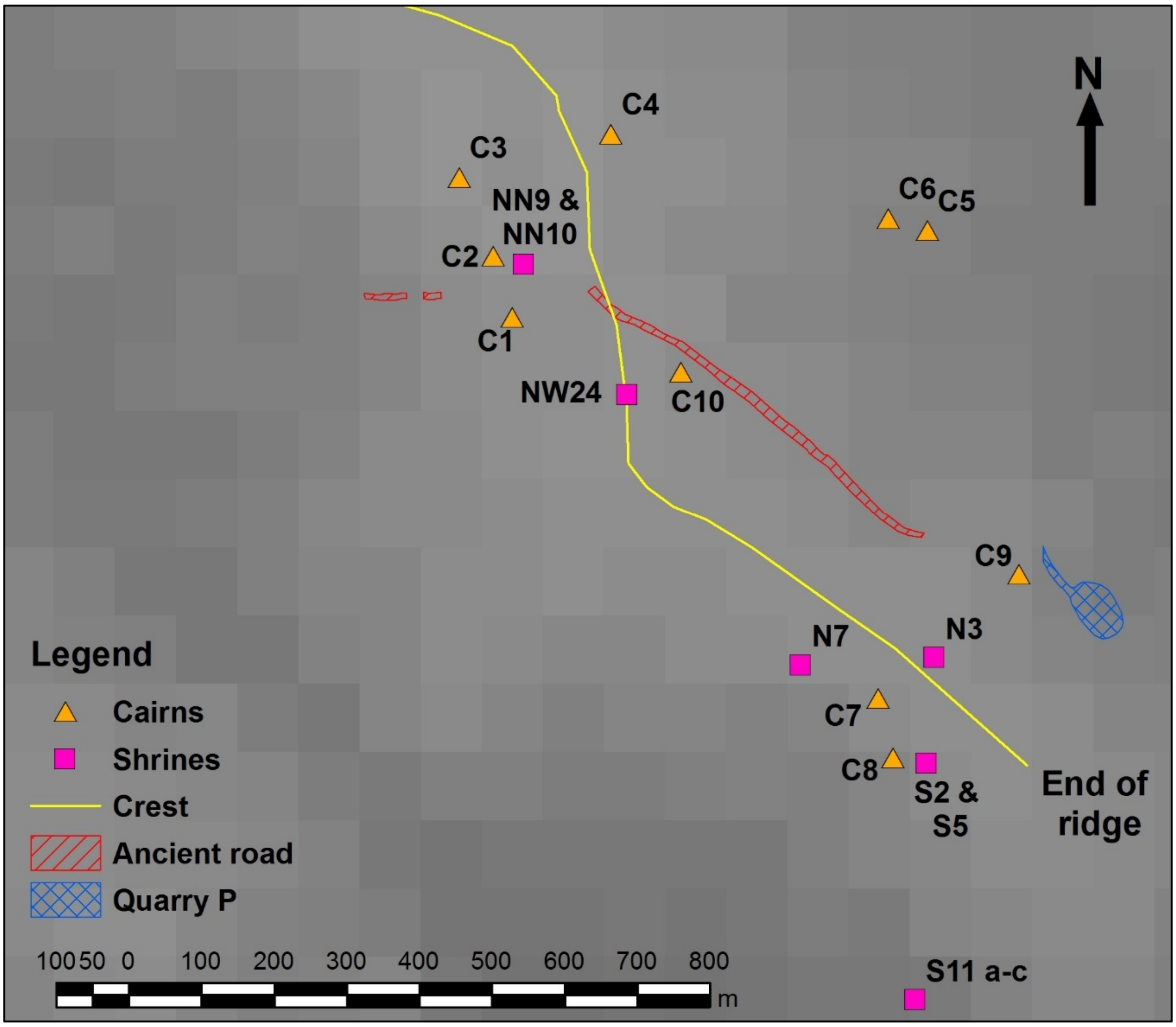


Fig 7.39: Detail of the SRTM showing the ridge with the Quarry P settlement in relation to the cairns and shrines. For clarity the crest of the ridge has been highlighted, as determined from the SRTM cell size. (SRTM data from the USGS)

Creating a series of cairns, located throughout the settlement, may even have been preferable to a few more limited specimens in the most prominent positions. It ensured that travellers from any direction would have sight of at least one of the cairns as they approached Quarry P.

Cairns spread throughout the settlement could also function as landmarks for major areas and key locations within it. Most of the cairns were surrounded by or close to areas of Old Kingdom settlement (Fig 7.20 and Fig 7.21), and could have functioned as markers for those moving between different parts of the site or returning to them in a subsequent expedition. This model of cairn construction also explains the relationship between the cairns and shrines. The cairns marked specific areas of settlement, including their associated shrines, which may have been constructed close to the cairns, so they could be found easily amongst the settlement structures.

This posited use of the cairns for aiding movement towards and through the site and marking areas of settlement and other activity is consistent with the use of navigational markers elsewhere. Riemer (2013) has investigated the use of inter-visible navigational markers (*alamat*) along the Abu Ballas trail in the Western Desert and the different arrangement of these features as a response to different types of landscape. The diffuse, but regular occurrence of cairns at Hatnub is consistent with the approach found along the Abu Ballas trail in hilly country and with the care taken to ensure the Abu Ballas trail was clearly visible from various directions. The construction of the Hatnub cairns off the crest of the ridge is also consistent with the approach to *alamat* construction seen on the Abu Ballas trail, where no more effort was expended than was sufficient to mark the route. Thus local materials were used and *alamat* were often placed on the flanks of hills, rather than on the very top.[361] Naturally the Hatnub cairns are much larger constructions, requiring far more effort than many of the *alamat* recorded by Riemer (2013). This is probably to ensure the Hatnub cairns were sufficiently distinctive to be visible in comparison to the stone huts, windbreaks and other structures of the settlement. It may also reflect the regular and repeat nature of the expeditions to Hatnub and perhaps some social aspects of the settlement. It is likely that the cairns were constructed by groups of workmen and either marked the settlements of different expeditions or different social or working groups.

The cairns can be divided into four groups based on their visibility. Three of these groups are quite similar to each other. The cairns within them are physically close to each other and have similarly sized viewsheds, which are associated with the same areas of landscape. All the cairns in all these groups have much larger projective than reflective viewsheds (Table 7.4):

1. Cairns C1 (HB1), C2 (HB2) and C3 (HB3) are located quite close to each other (Fig 7.20) and are close to shrines NN9 and NN10. Cairns C1–C3 all have similar viewsheds (Fig 7.23–Fig 7.25) that are of intermediate size, neither the largest nor the smallest (Table 7.4, Chart 7.2). Individually, their projective viewsheds (35.81–52.51km^2) are larger and dominated by the landscape to the south, while the

[361] For the classification of different approaches to route marking see Riemer (2013, 92; Fig 15). For efforts made to ensure the route was clear from both directions see Riemer (2013, 92–94). For the minimalist approach to *alamat* construction and location see Riemer (2013, 88–89).

reflective viewsheds (15.15–35.38km^2) are much smaller and dominated by the landscape to the west.

2. Cairn C5 (HB5) and C6 (HB6) are located on the north side of the settlement on some higher ground near a large group of structures. There are no shrines associated with the settlement around them (Fig 7.20). They are amongst the group of structures with the smallest viewsheds, but their projective viewsheds are still larger than their reflective viewsheds (Table 7.4, Chart 7.2). Both their projective and reflective viewsheds are dominated by the landscape to the east (Fig 7.27 and Fig 7.28).
3. Cairn C7 (HB7) and C8 (HB8) are located in the southern part of the site, south of Quarry P, on the 'peak' where petroglyphs were found close to cairn C7. Shrines S2 and S5, S11 a-c, N3 and N7 are located around cairns C7 and C8 (Fig 7.21). Although located close together, the viewsheds for these two cairns are quite different (Table 7.4, Chart 7.2). Cairn C7 has relatively large viewsheds, dominated by the landscape to the south and east of the site, while cairn C8 has very small viewsheds covering a small area to the south (Fig 7.29 and Fig 7.30). The differences between their viewsheds might suggest differences in date or function between cairns C7 and C8.

The larger projective viewsheds and distinct physical grouping of these cairns suggests that they represent three distinct areas of activity within the quarry. They may reflect different social groups or different periods of exploitation and there may also be more subtle second-order differences between the cairns in each group, such as those noted between cairns C7 and C8.

The fourth group is different. It comprises cairn C4 (HB4), C9 (HB9) and C10 (HB10). These cairns are not located close to each other, but they are also separate from the other three groups physically. They are dispersed through the settlement with C9 and C10 close to surviving sections of the ancient road. Cairn C9 is close to Quarry P (Fig 7.20 and Fig 7.21). The viewsheds of all these cairns are focussed upon the landscape to the east (Fig 7.26, Fig 7.31 and Fig 7.32), but are of very varied sizes. Cairn C4 has some of the largest viewsheds, while cairns C9 and C10 have much smaller viewsheds (Table 7.4, Chart 7.2). Unlike the other cairns, cairns C4, C9 and C10 all have much larger reflective than projective viewsheds, suggesting that visibility of them was important to their function.

Beyond C4, to the west are further cairns marking the route along the ancient road, although these have not been included here because they are not recorded on the published plans. It is possible that cairns C4, C9 and C10 represent a continuation of this line of cairns marking the route to Quarry P. Alternatively C4, C9 and C10 may be later infill cairns, constructed between the cairns of the other groups to ensure the settlement area was fully served by sufficient landmarks to facilitate navigation to and through it. Neither of these possibilities precludes cairns C4, C9 and C10 also serving as markers for areas of settlement, which may perhaps have developed around them secondarily.

Future research using a higher resolution DEM and either the actual cairn heights or a DEM including the cairns, could provide more details concerning the visibility of the cairns within the settlement, including which cairns were inter-visible with the shrines and how far the cairns in the four groups were inter-visible with each other. This might help refine the conclusions drawn here and reveal more about the differences and similarities between the cairns.

Dating and visibility

Both the inscriptions in Quarry P and the large quantity and wide distribution of Old Kingdom pottery across the settlement suggest an Old Kingdom date for most of the structures in the settlement. None of the cairns or shrines were located in the New Kingdom settlement around structures W1–51 and NW1–5 (Shaw 2010, 45–51), and the presence of both Old Kingdom and New Kingdom pottery at NW23 suggested that both NW23 and the adjacent shrine NW24 originated in the Old Kingdom and were later re-used in the New Kingdom (Shaw 2010, 71).

Apart from shrine NW24 only two of the observer points are associated with any specific dating evidence. Cairn C7, to the south of Quarry P, was tentatively dated to the Old Kingdom because of Old Kingdom parallels for the petroglyphs of feet and stairs at its base (Shaw 2010, 99). Elsewhere cairn C10 has a windbreak attached to its west side, where travertine chips and Old Kingdom pottery were found (Shaw 2010, 61). This reveals that cairn C10 must been built prior to the construction of the windbreak and the deposition of the Old Kingdom pottery.

The archaeological evidence suggests that all the cairns and shrines are either certainly or likely to be Old Kingdom in date, but it was hoped that the visibility analysis might help to improve understanding of the chronological development of the cairns or the shrines. Unfortunately the present results do not provide much additional information. If visibility was as significant in the location of the cairns at Hatnub as it was at Stelae Ridge, earlier cairns might be expected to have larger viewsheds. In this case cairns C3, C4 and C7 might be expected to be earlier, and cairns C5, C6 and C8 later, but it is very difficult to draw any definite conclusions when the evidence is so limited.

It is likely that the different settlement areas, with their cairns and shrines, developed over time with cairns being added as additional areas were occupied and new landmarks were required. If the groups of cairns posited in the previous section are correct, cairns C4, C9 and C10 of the fourth group, should either be interpreted as earlier structures, constructed to mark the route along the road to Quarry P, or as later structures created to fill in gaps which lacked landmarks. In either case the precise relationship between cairns C4, C9 and C10 and the other groups of cairns is unknown because it is difficult to distinguish any chronological pattern from the different visibilities of the cairns in the absence of any additional evidence.

A similar problem exists with the shrines, since they are also of the same general Old Kingdom date and are likely to have developed together with their adjacent settlements and cairns. It has already been suggested that NW24 was a shrine of particular significance attached to the administrative centre, NW23. Given the importance of NW23 during both the Old and New Kingdoms and its prominent position compared to the other cairns and shrines, it is possible that NW23 and NW24 were amongst the earlier of the structures created in the Quarry P settlement. If this is correct, larger viewsheds, particularly larger projective viewsheds, may be a feature of earlier shrines, but without additional evidence, it is impossible to say. The larger viewshed associated with NW24 may be purely accidental and visibility may have had nothing to do with the positioning of the other shrines.

Conclusion

Despite the more limited archaeological and textual context at Hatnub, the rapid visibility analysis did succeed in revealing more information about the cairns and shrines and suggested possible further avenues of research. Unlike Serabit el-Khadim, the viewsheds of the non-formal features at Hatnub did not exhibit any focus on a particular landscape feature or area. There was no relationship between the type of feature and the nature of its viewsheds, although there was a general positive correlation between the size of the projective and reflective viewsheds. Numerically the archaeological features were hard to group by viewshed size, although there was a group of cairns (C5, C6 and C8) and shrines (S2 and S5 and S11 a-c) with very small viewsheds of less than 20km^2 identifiable from Chart 7.2.

Detailed examination of the viewsheds revealed that the cairns were not located on the crest of the ridge, but off it to either side. This meant their reflective viewsheds were generally dominated by a limited number of directions and they were generally either visible from the south and west, or from the north and east. This also implies that it was not important to their builders to ensure the cairns were in the most-visible position, on the crest of the ridge, perhaps because creating more cairns off the crest ensured at least one would be visible from more of the landscape and, collectively, they could also assist movement through the settlement. The very wide visibility of the Hatnub cairns as a group is quite significant in terms of travel and access to the site. Although the quarry road has been identified leading west away from Quarry P towards the Nile valley (Shaw 2013), the distribution of the cairns suggests that people could approach the site from multiple directions. This could potentially include quarries R and T to the south-west and even from further east, where other unrecorded cairns are visible on distant hills.

The cairns could also be grouped into four groups, three of which were associated with different areas of settlement. The cairns in each of these three groups were physically close together and had similarly sized viewsheds, which were associated with the same areas of landscape. In the third group, the viewsheds of cairns C7 and C8 displayed some differences that might imply they were constructed at different times or for different functions. Despite this all the cairns in the three groups had larger projective than reflective viewsheds, suggesting they were constructed in places from which the landscape was highly visible, but not necessarily from where the cairns could be easily seen.

The fourth group comprised cairns C4, C9 and C10 and is quite different from the other three groups. The viewsheds of these cairns are more varied in size and, unlike the other three groups, their reflective viewsheds are larger than their projective viewsheds. This suggests that visibility of the cairns was important to the fourth group, which may have been created earlier to mark the route to Quarry P, or been later structures filling in gaps between the other cairns and their associated areas of settlement.

Shrine NW24 was closely associated with the administrative centre at NW23. Its importance is evident from its position on the crest of the ridge, with good visibility in all directions, although it is not certain whether this visibility had a practical purpose and is associated with NW23, a ritual purpose associated with NW24 or both.

7.4.4. Comparison between the visibility analysis of Stelae Ridge and the rapid visibility analysis of Serabit el-Khadim and Hatnub.

Table 7.5 shows the results of the projective visibility analysis of the Stelae Ridge courts undertaken without azimuths, and the reflective visibility of ground level at the Stelae Ridge cairns,[362] which are the results from Stelae Ridge most closely comparable to the data from Serabit el-Khadim and Hatnub.

Table 7.5: Projective viewsheds of the Stelae Ridge courts without azimuths, and reflective viewsheds of ground level at the Stelae Ridge cairns. (Data taken from Chapter 5, Table 5.11 and Table 5.17).

Cairn-court	Projective viewshed of the courts (without azimuths)		Reflective viewshed of ground level at the cairns.	
	Area (km^2)	Rank	Area (km^2)	Rank
I	121.51	3	169.42	4
II	121.26	5	168.85	5
III	121.32	4	169.62	3
IV	121.70	1	169.63	1
V	121.56	2	169.63	1
VI	113.78	6	72.71	7
VII	87.89	8	48.82	8
VIII	104.08	7	93.13	6

To aid comparison with the data from Serabit el-Khadim and Hatnub, Chart 7.3 shows the areas of the projective and reflective viewsheds of the Stelae Ridge cairn-courts plotted against each other. Table 7.6 details a comparison of the mean viewshed size for all three sites.

There are clear numerical differences between the viewsheds produced by the different sites, exemplified by the widely different mean viewshed sizes and the different groups of archaeological features evident in Charts 7.1–7.3. These differences are products of a combination of the different topography at each site and the distribution of non-formal archaeological features across that terrain. They reflect different responses to the desert landscape in accordance with the specific terrain and the practical, social and ritual requirements of any given site.

---

[362] For the projective visibility analysis of the Stelae Ridge courts without azimuths see Chapter 5, section 5.2.2, and for the reflective visibility analysis of ground level at the Stelae Ridge cairns see Chapter 5, section 5.4.1.

Chart 7.3: Projective and reflective viewsheds of the Stelae Ridge cairn-courts plotted against each other. Data taken from Table 7.5.

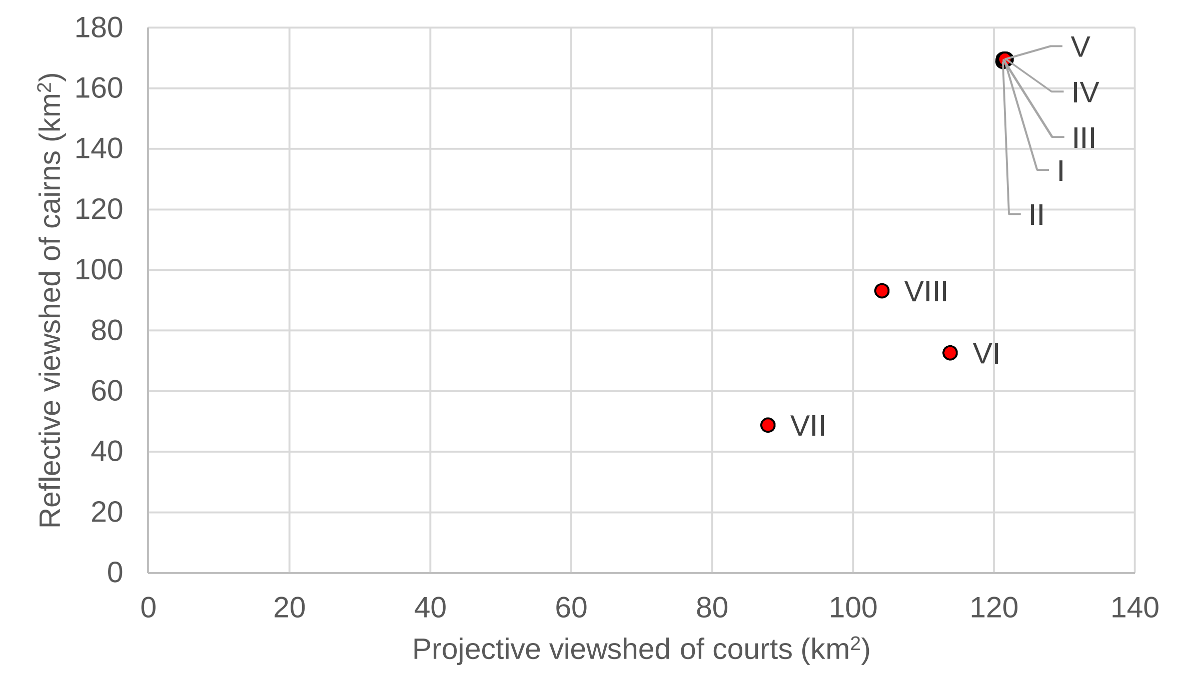


Table 7.6: Mean projective and reflective viewshed sizes for the Stelae Ridge cairn-courts, Serabit el-Khadim stelae and enclosures and Hatnub shrines and cairns.

	Mean viewshed size (km^2)	
Site	**Projective**	**Reflective**
Stelae Ridge	114.14	132.73
Serabit el-Khadim	74.17	66.29
Hatnub	32.40	25.05

The mean viewshed size for the Stelae Ridge cairn-courts is much bigger than the mean viewshed size for Serabit el-Khadim and Hatnub. At Stelae Ridge, the reflective viewsheds are also much bigger than the projective viewsheds, whereas at the other sites it is the opposite.[363] The much larger viewsheds at Stelae Ridge are due to the very flat and open

[363] This is probably partly because the reflective viewsheds of the Stelae Ridge cairns represent a position on the crest of Stelae Ridge, rather than the position slightly east of the crest occupied by the projective viewsheds of the Stelae Ridge courts. However Table 5.11 in Chapter 5 shows that the reflective viewsheds of the courts are quite similar in size to the reflective viewsheds of the cairns. The mean reflective viewshed size for the courts without azimuths is 130.99km^2, which is still larger

landscape, but the mean may also be influenced by the close proximity of the cairn-courts to each other. The archaeological features at both Serabit el-Khadim and Hatnub are located in much more varied terrain and are spread much more widely across the landscape than at Stelae Ridge.

Consideration of mean viewshed size in comparison with viewshed extent suggests several differences between the sites. Collectively the viewsheds at Serabit el-Khadim are much more limited to a relatively small segment of landscape to the north of the site, while the viewsheds at Hatnub and Stelae Ridge collectively include more of the 360° around the sites. It is therefore notable that Serabit el-Khadim has larger mean viewsheds than Hatnub, even though those viewsheds occupy a much smaller area of the landscape. This reflects the different foci of the viewsheds at the different sites. At Hatnub, the cairns were collectively visible from all around, even if their viewsheds were individually more restricted, reflecting a potentially wide range of approaches to the sites. At Serabit el-Khadim, the stelae and enclosures were focussed on the south-west to north-east approach to the temple and did not require visibility of the landscape beyond to be effective as landmarks on the route to the temple. At Stelae Ridge the cairn-courts had quite wide visibility, but were more focussed on approaches to the site from the south.

The different foci of the viewsheds from the three different sites clearly relate to the role of the non-formal structures in marking routes and navigating to, from and around the sites. The visibility analysis provided evidence that the Stelae Ridge cairn-courts, Serabit el-Khadim stelae and enclosures, and Hatnub cairns were all involved in navigation to a greater or lesser extent. This is highly significant for the interpretation of these structures and relates them to a broader group of archaeological features.[364] The archaeological features at Serabit el-Khadim and Stelae Ridge are particularly significant in this respect, because there is evidence that these landmarks also had a ‘ritual’ component, exemplified by the artefacts and inscriptions found at them. This raises the wider question of the relationship between the practical and ritual functions of such structures and the issue of ritualisation referred to previously in section 7.2.1. The inter-visibility between the Hatnub shrines and the nearest

---

than mean size of the projective viewshed and indicates that the much larger reflective viewsheds are not due to the slightly different position of the courts and cairns on the ridge.

[364] For various papers discussing roads and road marking see Bard *et al.* (2013); Bubenzer and Bolton (2009); Bülow-Jacobsen (2013); Bloxam *et al.* (2014); Darnell and Darnell (1993; 1994; 2013); Darnell *et al.* (2002); Förster (2007; 2013); Harrell and Brown (1995); Harrell and Storemyr (2009); Heldal (2009); Hendrickx *et al.* (2013); Hoffmeier and Moshier (2013); Kelany *et al.* (2009); Riemer (2013); Riemer and Förster (2013); Rossi and Ikram (2013); Shaw (2010, 109–114; 2013); Snape (2013); Somaglino and Tallet (2013); Storemyr *et al.* (2013). For other examples of cairns used as landmarks see Engelbach (1939); Shaw (2006; 2013).

cairns may also include some element of ritualisation of the cairns, particularly in the case of cairn C7, which attracted petroglyphs. However, the close proximity of shrines to cairns is also likely to relate to the role of the cairns as landmarks for different areas of the settlement, including any nearby shrines.

Another similarity between the results from Stelae Ridge and those from Serabit el-Khadim is the apparent tension between visibility and seclusion in the construction of the non-formal features. The rapid visibility analysis of Serabit el-Khadim suggested that the earlier stelae and enclosures dating to the reign of Senusret I privileged visibility. The later temple was located in a position that gave it a dramatic backdrop against the Wadi Garf and the Tih escarpment, but was not in the most prominent position. The far group of stelae and enclosures on the approach had very restricted visibility that only opened up as one reached the middle group. The views constructed by the approach to the temple at Serabit el-Khadim combined with the hidden nature of the sanctuary itself, reflects the same tension as at Stelae Ridge between seclusion for the core ritual area, and visibility for its external components.

The almost non-existent evidence for a ritual function for most of the Hatnub cairns may be related to either the earlier date of the structures or to the geographical position of the site. It may be that the Old Kingdom cairns at Hatnub pre-date the ritualisation of navigational markers, which is visible at the Middle Kingdom sites of Stelae Ridge and Serabit el-Khadim. A temporal view of the development of the ritual structures would also be consistent with the change in emphasis at Serabit el-Khadim from non-formal stelae and enclosures in the early Middle Kingdom to a ‘formal’ temple with rock-cut shrine in the later Middle Kingdom.

Alternatively, both Serabit el-Khadim and Stelae Ridge are located much further from the Nile valley than Hatnub. The proximity of Hatnub to the Nile valley may have rendered it more familiar territory than Stelae Ridge and Serabit el-Khadim and made extensive ritualisation of the cairns unnecessary. It may be significant that while texts at both Stelae Ridge and Serabit el-Khadim reference the goddess Hathor, who is widely associated with foreign countries and mining in general,[365] the texts in Quarry P at Hatnub refer to other gods or deities local to the adjacent parts of the Nile valley. Hathor is noticeable by her absence (Shaw 201, 106–107).

---

[365] For the texts at Stelae Ridge see Darnell and Manassa (2013). For the texts at Serabit el-Khadim see Bloxam (2006, 282); Černy *et al.* (1955); Valbelle and Bonnet (1996, 36). For the association between Hathor and mining in foreign countries see Valbelle and Bonnet (1996, 36–42; 120–123).

The viewsheds from the different sites may contribute some evidence about the familiarity of the sites in the minds of the workers. Whether or not travel to the temple at Serabit el-Khadim was aided by other navigational markers which have not been included here, the viewsheds of the stelae and enclosures that were included in the visibility analysis make little allowance for travel to the temple from multiple directions, but are rather heavily focussed upon the view northwards past the temple into the Wadi Garf. The viewsheds of the Stelae Ridge cairn-courts are more open but still display a strong emphasis upon routes from the south. By contrast at Hatnub the viewsheds of the cairns ensured landmarks were visible to people approaching from all directions, perhaps suggesting greater use of this part of the desert and the improved familiarity that results from greater knowledge of an area. This familiarity could explain why Hatnub was felt to be part of the Nile valley and subject to the local gods of the area, rather than a foreign land requiring the intervention of Hathor. Equally, the very distant location of Serabit el-Khadim may have meant that non-formal approaches to ritual, such as those undertaken at the Stelae Ridge cairn-courts, were felt to be insufficient to manage the alien environment and a more typical temple was necessary.

At Stelae Ridge differences in visibility were related to the chronological development of the cairn-courts, specifically the development of structures from the southern ridge northwards onto Stelae Ridge north. Earlier structures had larger viewsheds and later structures had more restricted visibility, allowing for the ridge on which they were located, and more peripheral locations. The viewsheds contributed to a model for the chronological development of the ridge, which was consistent with the textual evidence and provided a reasonable chronological framework that included the undated cairn-courts. At Hatnub it was not possible to use the rapid visibility analysis to suggest the chronological order of the archaeological features, although it is possible that more detailed visibility analysis may reveal more. At Serabit el-Khadim there was no consistent link between date and visibility, but it was possible to integrate the results of the visibility analysis with the known dates of the stelae to give some temporal quality to the resulting interpretation.

7.4.5. Conclusion

The rapid visibility analysis of non-formal features at Serabit el-Khadim and Hatnub was undertaken in order to assess the value of this method when applied to other sites and give some idea of what might be learned by comparing the results of visibility analysis at different sites.

It is clear that the application of the method to two additional sites was able to produce new information and interpretations of the archaeological features at those sites, just as it did at Stelae Ridge. In each case, the visibility analysis allowed the archaeological features to be divided into distinct groups, either on the basis of the sizes of their viewsheds or in terms of the areas visible, or both. The archaeological and visual properties of these groups then allowed further interpretations of the archaeological features within them, and suggested possible questions and avenues for future research.

Comparison of the similarities and differences between the three sites was also illuminating. Evidence from the visibility analysis suggested that non-formal features at all three sites functioned as landmarks for those moving towards and between the sites. Differences in the areas of landscape focussed on by the viewsheds was linked to different approaches to each site. While Hatnub could be approached from many directions, Serabit el-Khadim and Stelae Ridge had more restricted connections.

At both Stelae Ridge and Serabit el-Khadim the non-formal features had both practical and ritual functions and exhibited a tension between visibility and seclusion. This suggests that a wider study of ritualisation and the tension between the revealed and the hidden may be beneficial.

The inclusion of multiple sites also allowed for consideration of temporal and archaeological differences between the sites. The inclusion of Hatnub extended the timescale into the Old Kingdom, while Serabit el-Khadim allowed consideration of the relationship between non-formal archaeological features and a more typical Egyptian temple. The differences between the sites may reflect temporal changes, or the effect of a site’s remoteness and inaccessibility upon the types of structures created.

Further visibility analysis of other similar sites may resolve some of the questions about the development of non-formal archaeological features over time and their relationship with the remoteness of such sites. It may also reveal more about how far the interpretations of the non-formal features from Stelae Ridge, Serabit el-Khadim and Hatnub can be applied more generally to this type of archaeology. The rapid visibility analysis of Hatnub has shown that where archaeological and epigraphic evidence is more limited, the visibility analysis may not be able to answer the same questions, but it can reveal new interpretations and engender new avenues of research.

In addition to further research at Hatnub and Serabit el-Khadim, Gebel el-Zeit, Wadi el-Hudi and Mersa Gawasis are all potential candidates for this type of visibility analysis. Outside of mining and quarrying contexts it is clear from the references in Chapter 1, footnote 16, that non-formal structures, particularly cairns, occur widely along routes through the Egyptian deserts. Visibility analysis of these features could provide insights into Egyptian navigation and prospection and would also prove useful for comparisons with the non-formal structures from mines and quarries. Studies of such features would provide a useful counterpoint to epigraphic and traditional archaeological survey along desert routes.[366]

7.5. Theoretical and methodological implications of the research

The debate over GIS, discussed in Chapter 1, section 1.3.2, has closed dialogue between the different communities working with GIS and other approaches to ancient landscapes. This has placed limitations upon the applications of GIS research and interest in it (Gillings 2012, 602–604). The research presented in this thesis is evidence that GIS visibility analysis can be used successfully as a tool for the development of research data to answer archaeologically meaningful questions.

However, the contextualisation of the results of the GIS research is key. Without it, the conclusions of this research would have been limited to (1) the revelations made in Chapter 5, namely that the structures on Stelae Ridge south have better views and are more visible than those on Stelae Ridge north and (2) that testing the visibility analysis has shown that this result is reasonably robust despite some limitations. While personal experience of visibility at the site suggests that these conclusions are true, they do not contribute much to the interpretation of the chronology, function and relationships between the cairn-courts and their landscape, unless they are considered in the light of the other available evidence from archaeology, epigraphy and the Middle Kingdom cultural context. The hermeneutic reassessment, reinterpretation and interrogation of the results of the GIS visibility analysis is therefore key to the development of truly meaningful interpretations of the site. These interpretations provide a new understanding of archaeological features, sites and landscapes and provide a foundation for further research.

7.6. Concluding remarks

As researchers working with Egyptian material engage with methods and theories from world archaeology, they are pushing research beyond traditional questions, sources and methods of investigation. Answering new questions and investigating sites not amenable to traditional methods of investigation necessitates the adoption of new approaches and analytical techniques, not previously employed in the discipline of Egyptology or Egyptian archaeology.

---

[366] For archaeological and epigraphic survey of desert routes see publications including Bard *et al.* (2013); Bubenzer and Bolton (2009); Bülow-Jacobsen (2013); Bloxam *et al.* (2014); Darnell and Darnell (1993; 1994; 2013); Darnell *et al.* (2002); Förster (2007; 2013); Harrell and Brown (1995); Harrell and Storemyr (2009); Heldal (2009); Hendrickx *et al.* (2013); Hoffmeier and Moshier (2013); Kelany *et al.* (2009); Riemer (2013); Riemer and Förster (2013); Rossi and Ikram (2013); Shaw (2010, 109–114; 2013); Snape (2013); Somaglino and Tallet (2013); Storemyr *et al.* (2013).

This thesis has presented a new approach to the investigation of non-formal desert structures through GIS visibility analysis, never previously undertaken in an Egyptian context. The successful analysis and re-interpretation of the eight cairn-courts at Stelae Ridge has demonstrated the potential of this method to provide new data for analysis. Contextualisation of the GIS visibility analysis using the archaeological, epigraphic, phenomenological, cultural and historical evidence from the site enabled archaeologically meaningful conclusions to be drawn and helped to avoid some of the methodological and theoretical snares that have beset GIS visibility analysis elsewhere in the past. The resulting method of systematic GIS visibility analysis provides a useful new approach to the investigation of non-formal desert structures and a new direction in GIS research and visibility analysis in Egyptology.

Bibliography

Abbreviations

AA – American Antiquity.

AJA – American Journal of Archaeology.

ASAE – Annales des Service des Antiquités de l'Égypte.

BAR – British Archaeological Reports.

BIFAO – Bulletin de l'Institut Français d'Archéologie Orientale du Caire.

CAJ – Cambridge Archaeological Journal.

CGIS – Cartography and Geographic Information Science.

DAIK – Deutsches Archäologisches Instituts, Abteilung Kairo.

DMA – Defense Mapping Agency (United States).

EA – Egyptian Archaeology.

EJA – European Journal of Archaeology.

FIFAO – Fouilles de l'Institut Français d'Archéologie Orientale du Caire.

GM – Göttinger Miszellen.

IFAO – Institut Français d'Archéologie Orientale du Caire.

JAMT – Journal of Archaeological Method and Theory.

JARCE – Journal of the American Research Center in Egypt.

JAS – Journal of Archaeological Science.

JEA – Journal of Egyptian Archaeology.

JNES – Journal of Near Eastern Studies.

LÄ – Lexikon der Ägyptologie.

MDAIK – Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo.

MIFAO – Mémoires de l'Institut Français d'Archéologie Orientale du Caire.

NGA – National Geospatial-Intelligence Agency (United States).

USGS – United States Geological Survey.

WA – World Archaeology.

ZÄS – Zeitschrift für Ägyptische Sprache und Altertumskunde.

Bibliography

Abdel Maguid, Z. R. 2011. Les carrières de Gebel el-Silsilah. *ASAE* 85: 21–32.

Abd el-Raziq, M. Castel, G. Tallet, P. Ghica, V. Passera, N. Gout,J-F. Menassa, L. and Zaza, K. 2002. *Les Inscriptions d'Ayn Soukhna*. MIFAO 122. Cairo: IFAO.

Abd el-Raziq, M. Castel, G. Tallet, P. Fluzin, P. 2011. *Ayn Soukhna II: Les Ateliers Métallurgiques du Moyen Empire*. FIFAO 66. Cairo: IFAO.

Abd el-Raziq, M. Castel, G. Tallet, P. and Marouard, G. 2012. The Pharaonic site of Ayn Soukhna in the Gulf of Suez: 2001–2009 Progress Report. In: P. Tallet and El-Sayed Mahfouz (eds.) *The Red Sea in Pharaonic Times: Recent Discoveries along the Red Sea Coast. Proceedings of the Colloquium held in Cairo/Ayn Soukhna 11th–12th January 2009.* IFAO 155: Cairo. 3–20.

Abu-Jaber, N. Bloxam, E. G. Degryse, P. and Heldal, T. (eds.) 2009 *QuarryScapes: Ancient Stone Quarry Landscapes in the Eastern Mediterranean.* Oslo: NGU, Norges geologiske undersøkelse.

Aldred, C. 1976. The horizon of the Aten. *JEA* 62: 184.

Anthes, R. 1928. *Die Felsinschriften von Hatnub.* Untersuchungen zur Geschichte und Altertumskunde Ägyptens 9. Leipzig: J. C. Hinrichs.

Arnold, 1974. *Der Tempel des Königs Mentuhotep von Deir el-Bahri I: Architektur und Deutung.* DAIK 8. Cairo

Assmann, J. 1970. *Der König als Sonnenpriester: Ein kosmographischer Begleittext zur kultischen Sonnenhymnik.* DAIK 7. Cairo.

Assmann, J. 1995. *Egyptian Solar Religion in the New Kingdom: Re, Amun and the crisis of polytheism.* Trans. A. Alcock. London and New York: Kegan Paul International.

Assmann, J. 2001. *The Search for God in Ancient Egypt.* Trans. D. Lorton. New York: Cornell University Press.

Aston, B. G. Harrell, J. and Shaw, I. 2001. Stone. In: P. Nicholson and I. Shaw (eds.) *Ancient Egyptian Materials and Technologies.* Cambridge: Cambridge University Press. 5–77.

Aufrère, S. 1983. Caractères principaux et origine divine des minéraux. *Revue d'Égyptologie* 34: 3–21.

Aufrère, S. 1991. *L'Univers Minéral dans la Pensée Égyptienne.* Cairo: IFAO.

Aufrère, S. 1997. L'univers minéral dans la pensée Égyptienne; Essai de synthèse et perspectives (Autour de l'univers minéral X). *Archéo-Nil.* 7: 113–144.

Aufrère, S. 2001. The Egyptian temple – Substitute for the mineral universe. In: W. V. Davies (ed.) *Colour and Painting in Ancient Egypt.* London: British Museum Press. 158–163.

Baines, J. 1984. Interpretation of religion: Logic, discourse, rationality. *GM* 76: 25–54.

Baines, J. 1987. Practical Religion and Piety. *JEA* 73: 79–98.

Baines, J. 1991. Society, Morality and Religious Practice. In: B. Shafer (ed.) *Religion in Ancient Egypt.* London: Routledge. 123–201.

Baines, J. 2007. *Visual and Written Culture in Ancient Egypt.* Oxford University Press: Oxford.

Ball, J. 1927. Problems of the Libyan desert. *Geographical Journal* 70: 21–83, 105–128, 209–224, 512.

Bard, K. A. and Fattovich, R. 2013a. The land of Punt and recent archaeological and textual evidence from the Pharaonic harbour at Mersa/Wadi Gawasis, Egypt. In: S. Chrisomalis, and A. Costopoulos (eds.) *Human Expeditions: Inspired by Bruce Trigger*. Toronto: University of Toronto Press. 3–11.

Bard, K. A. Fattovich, R. and Manzo, A. 2013b. The ancient harbour at Mersa/Wadi Gawasis and how to get there: New evidence of Pharaonic seafaring expeditions in the Red Sea. In: F. Förster, F. and H. Riemer, (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Köln: Heinrich-Barth-Institut. 533–556.

Barrett, J. C. 2004. Comment on C. Tilley, 'Round barrows and dykes as landscape metaphors'. *CAJ* 14.2: 199.

Barrett, J. C. and Ko, I. 2009. A phenomenology of landscape: A crisis in British landscape archaeology? *Journal of Social Archaeology* 9: 275–295.

Barrowclough, D. A. and Malone, C. (eds.) 2007. *Cult in Context: Reconsidering Ritual in Archaeology.* Oxford. Oxbow.

Batey, E. K. 2008. Palaeodemography in Predynastic Upper Egypt: Investigations of the working class cemetery at Hierakonpolis. In: Midant-Reynes, B. and Tristant, Y. (eds.) *Egypt at its Origins 2: Proceedings of the International Conference "Origin of the State. Predynastic and Early Dynastic Egypt", Toulouse (France), 5th–8th September 2005.* Leuven: Peeters and Departement Oosterse Studies. 249–264.

Beck, A. Phillip, G. Abdulkarim, M. and Donoghue, N. 2002. Evaluation of Corona and Ikonos high resolution satellite imagery for archaeological prospection in western Syria. *Antiquity* 80: 161–175.

Bell, B. 1971. The Dark Ages in ancient history: 1. The first Dark Age in Egypt. *AJA* 75: 1–26.

Bell, C. 1993. *Ritual Theory, Ritual Practice.* Oxford: Oxford University Press.

Bell, C. 1997a. *Ritual: Perspectives and Dimensions.* Oxford: Oxford University Press.

Bell, L. 1997b. The New Kingdom 'divine' temple: The example of Luxor. In: B. E. Shafer (ed.) *Temples of Ancient Egypt.* New York: Cornell University Press. 127–184.

Bellandi, G. De Marzo, R. Benazzi, S. and Sesana, A. 2014. Burials under the temple of millions of years of Amenhotep II – Luxor, West Thebes. In: Ikram, S. Kaiser, J. and Walker, R. (eds.) 2014. *Egyptian Bioarchaeology: Humans, Animals, and the Environment.* Sidestone Press. 19–32.

Bender, B. Hamilton, S. and Tilley, C. 1997. Leskernick. Stone Worlds; alternative narratives; nested landscapes. *Proceedings of the Prehistoric Society* 63: 147–178.

Bender, B. Hamilton, S. and Tilley, C. 2007 *Stone Worlds: Narrative and Reflexivity in Landscape Archaeology*. London: Publications of the Institute of Archaeology, UCL.

Bertemes, F, Biehl P. F. and Meller H. (eds.) 2001. *The Archaeology of Cult and Religion.* Budapest.

Betrò, M. and Del Vesco, P. 2006. Dra Abu l'Naga (Gurna, Luxor – Egitto): Campagne III-V (2004–2005). *Egitto e Vicino Oriente* 29: 5–64.

Betrò, M. Del Vesco, P. Ghiroldi, A. Lippi, B. and Facchetti, F. 2007. Preliminary report on the University of Pisa 2007 season in TT14 and MIDAN 05. *Egitto e Vicino Oriente* 30: 23–40.

Bewley, R. and Raczkowski, W. (eds.) 2002 *Aerial Archaeology: Developing Future Practice.* Oxford: IOS Press.

Blackden, M. W. and Fraser, G. W. 1892. *Collection of Hieratic Graffiti from the Alabaster Quarry of Hat-nub.* Private Collection.

Blackman, A. M. 1918. Purification (Egyptian). In: Anonymous (ed.) *Hastings Encyclopaedia 10.* 476–482*.* Republished in: A. B. Lloyd (ed.) 1998. *Gods, Priests and Men: Studies in the Religion of Pharaonic Egypt by Aylward M. Blackman.* London and New York: Kegan Paul International. 3–21.

Blackman, A. M. and Fairman, H. W. 1946. The consecration of an Egyptian Temple according to the use of Edfu. *JEA* 32: 75–91. Republished in: A. B. Lloyd (ed.) 1998. *Gods, Priests and Men: Studies in the Religion of Pharaonic Egypt by Aylward M. Blackman.* London and New York: Kegan Paul International. 326–342.

Bloxam, E. 2000. Transportation of quarried hard stone from Lower Nubia to Giza during the Old Kingdom. In: A. McDonald, and C. Riggs (eds.) *Current Research in Egyptology 2000.* BAR International Series 909. Oxford: Archaeopress. 19–28.

Bloxam, E. 2003a. An alternative strategy for the transportation of quarried hard stone from Lower Nubia to Giza during the Old Kingdom. In: Z. Hawass and L. Pinch-Brock (eds.) *Egyptology at the Dawn of the Twenty-First Century: Proceedings of the Eighth International Conference of Egyptologists, Cairo, 2000.* Cairo: American University in Cairo Press. 86–91.

Bloxam, E. 2003b. *The Organisation, Transportation and Logistics of Hard Stone Quarrying in the Egyptian Old Kingdom: A Comparative Study.* Unpublished PhD Thesis: University of London. Downloaded from http://ethos.bl.uk. uk.bl.ethos.408254 last accessed 15 August 2014.

Bloxam, E. 2005. The organisation and mobilisation of Old Kingdom quarry labour forces at Chephren's Quarry (Gebel el-Asr) Lower Nubia. In: A. Cooke and F. Simpson (eds.) *Current Research in Egyptology II, 2001.* BAR International Series 1380. Oxford: Archaeopress. 11–20.

Bloxam, E. 2006. Miners and mistresses: Middle Kingdom mining on the margins. *Journal of Social Archaeology* 6: 277–303.

Bloxam, E. Harrell, J. Kelany, A. Moloney, N. el-Senussi, A. and Tohamey, A. 2014. Investigating the Predynastic origins of greywacke working in the Wadi Hammamat. *Archéo-Nil* 24, 11–30.

Blumenthal, E. 1977. Die Textgattung Expeditionsbericht in Ägypten. In: J. Assmann, E. Feucht and R. Grieshammer (eds.) *Fragen an die Altägyptische Literatur: Studien zum Gedenken an Eberhard Otto.* Wiesbaden. 86–118.

Bomann, A. H. 1991. *The Private Chapel in Ancient Egypt.* London and New York: Kegan Paul International.

Bommas, M. 2003. Schrein unter: Gebel es-Silsilah im Neuen Reich. In: H. Guksch, E. Hofmann, and M. Bommas (eds.) *Grab und Totenkult im Alten Ägypten*. München: Beck. 88–103.

Bonnet, C. 1998. Le Sanctuaire d'Hathor à Sérabit el-Khadim et la Topographie Urbaine. In: D. Valbelle and C. Bonnet (eds.) *Le Sinai Durant l'Antiquité et le Moyen Age: 4000 ans d'Histoire pour un Désert.* Paris: Editions Errance. 44–49.

Bonnet, C. and Valbelle, D. 1997. The Middle Kingdom temple of Hathor at Serabit el-Khadim. In: S. Quirke (ed.) *The Temple in Ancient Egypt: New Discoveries and Recent Research.* London: British Museum Press. 82–89.

Borchardt, L. 1897. Ein Ägyptisches Grab aus Sinaihalbinsel. *ZÄS* 35*:* 112–115.

Bradley, R. 2005. *Ritual and Domestic Life in Prehistoric Europe.* London and New York: Routledge.

Briault, C. 2007. Making mountains out of molehills in the Bronze Age Aegean: Visibility, ritual kits, and the idea of a peak sanctuary. *WA* 39.1: 122–141.

Brock, J. C. Wright, C. W. Sallenger, A. H. Krabill, W. B. and Swift. R. N. 2002. Basis and methods of NASA Airbourne Topographic Mapper LiDAR surveys for coastal studies. *Journal of Coastal Research* 18: 1–13.

Brück, J. 1998. In the footsteps of the ancestors. A review of Tilley's 'A phenomenology of landscape. Places, paths and monuments'. *Archaeological review from Cambridge* 15: 23–36.

Brück, J. 1999. Ritual and rationality: Some problems of interpretation in European archaeology. *EJA* 2.3: 313–344.

Brück, J. 2005. Review essay: Experiencing the past? The development of a phenomenological archaeology in British prehistory. *Archaeological Dialogues* 12.1: 45–72.

Bubenzer, O. and Bolton, A. 2013. Top down: New satellite data and ground-truth data as base for a reconstruction of ancient caravan routes. Examples from the Western Desert of Egypt. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 61–76.

Bubenzer, O. and Riemer, H. 2007. Holocene climatic change and human settlement between the central Sahara and the Nile Valley: Archaeological and geomorphological results. *Geoarchaeology: An International Journal.* 22.6: 607–620.

Bülow-Jacobsen, A. 2013. Communication, travel, and transportation in Egypt's Eastern Desert during Roman times (1st to 3rd century AD). In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 557–574.

Bunbury, J. M. 1999. *Geological section and description of the rock types for the area of the Gebel el-Asr gneiss quarries.* Unpublished report.

Bunbury, J. M. and Ikram, S. 2014. Kharga Oasis: A Saharan patchwork of lakes. *EA* 45: 9–12.

Bunbury, J. M. and Jeffreys, D.J. 2011. Real and literary landscapes in Ancient Egypt. *CAJ* 21.1: 65–76.

Bunbury, J. M. Graham, A. and Strutt, K. D. 2009. Kom el-Farahy: A New Kingdom island in an evolving Edfu floodplain. *British Museum studies in ancient Egypt and Sudan* 14: 1–23.

Burrough, P. A. 1986. *Principles of Geographical Information Systems for Land Resources Assessment.* Oxford: Clarendon Press.

Burrough, P. A. and McDonald, R. 1998. *Principles of Geographical Information Systems.* Oxford: Oxford University Press.

Bussmann, R. 2010. *Die Provinztempel Ägyptens von der 0. bis zur 11. Dynastie: Archäologie und Geschichte einer gesellschaftlichen Institution zwischen Residenz und Provinz.* Leiden: Brill.

Bussmann, R. 2011. Local traditions in early Egyptian temples. In: R. F. Friedman and P. N. Fiske (eds.) *Egypt at its Origins 3: Proceedings of the Third International Conference "Origin of the State. Predynastic and Early Dynastic Egypt", London, 27th July – 1st August 2008.* Orientalia Lovaniensia Analecta 205. Leuven, Paris and Walpole, MA: Uitgeverij Peeters. 747–762.

Butzer, K. 1961. Archäologische Fundstellen Ober- und Mittelägyptens in ihrer geologischen Landschaft. *MDAIK* 17: 54–68.

Butzer, K, 1982. *Archaeology as Human Ecology.* London.

Buzon, M. R. 2006. Life in New Kingdom Nubia: A bioarchaeological analysis of ethnicity, biological affinities and health. In: I. Caneva, and A. Roccati (eds.) *Acta Nubica: Proceedings of the X International Conference of Nubian Studies, Rome 9-14 September 2002.* Roma: Instituti Poligrafico e Zecca dello Stato. 213–218.

Caminos, R. A. and James, T. G. H. 1963. *Gebel es-Silsilah I: The Shrines*. Archaeological Survey of Egypt 31. London: Egypt Exploration Society.

Campana, S. Forte, M. and Liuzza, C. (eds.) 2010. *Space, Time, Place: Third International Conference on Remote Sensing in Archaeology.* BAR International Series 2118. Oxford: Archaeopress.

Carr, T and Turner, M. 1996. Investigating regional lithic procurement using multispectral imagery and geophysical exploration. *Archaeological Prospection* 3: 109–127.

Carrara, A. Bitelli, G. and Carla, R. 1997. Comparison of techniques for generating digital terrain models from contour lines. *International Journal of Geographical Information Science* 11: 451–474.

Casana, J. and Cothren, J. 2008. Stereo analysis, DEM extraction and orthorectification of CORONA satellite imagery: Archaeological applications from the Near East. *Antiquity* 82: 732–749.

Casana, J. Cothren, J. and Kalayci, T. 2012. Swords into ploughshares: Archaeological applications of CORONA satellite imagery in the Near East. *Internet Archaeology* 32. Available from http://dx.doi.org/10.11141/ia.32.2 last accessed 7th November 2014.

Castel, C and Soukiassian, G. 1985a. Dépôt de Stèles dans le Sanctuaire du Nouvel Empire au Gebel Zeit. *BIFAO* 85: 285–293.

Castel, C. and Soukiassian, G. 1985b. Les Mines de Galene du Gebel Zeit. In: S. Schoske (ed.) *Akten des Vierten Internationalen Ägyptologen Kongresses, München 1985.* Hamburg: Helmut Buske Verlag. 161–170.

Castel, C. and Soukiassian, G. 1989. *Gebel Zeit I: Les Mines de Galène.* FIFAO 35. Cairo: IFAO.

Černy, J. 1952. *Ancient Egyptian Religion.* London: Hutchinson.

Černy, J. Gardiner, A. H. and Peet, T. E. 1955. *The Inscriptions of Sinai II. 2nd Edition.* London: Egypt Exploration Society.

Chadwick, A. 2004. Geographies of sentience – an introduction to space, place and time. In: A. Chadwick (ed.) *Stories from the landscape. Archaeologies of Inhabition.* BAR International Series 1238. Oxford: Archaeopress. 1–31.

Chapman, H. 2005. Re-thinking the ‘cursus problem’ – investigating the landscape archaeology of Rudston, East Yorkshire, UK, using GIS. *Proceedings of the Prehistoric Society* 71: 159–170.

Chapman, H. 2006. *Landscape Archaeology and GIS.* Tempus.

Chapman, H. and Geary, B. 2000. Palaeoecology and the perception of prehistoric landscapes: Some comments on visual approaches to phenomenology. *Antiquity* 74: 316–319.

Couyat, J. and Montet, P. 1912. *Les Inscriptions du Ouâdi Hammâmât.* MIFAO 34. Cairo: IFAO.

Conolly, J. and Lake, M. 2006. *Geographical Information Systems in Archaeology.* Cambridge: Cambridge University Press.

Corrie, R. K. 2011. Detection of ancient Egyptian archaeological sites using satellite remote sensing and digital image processing. In: *Proceedings of the Society of Photo-Optical Instrumentation Engineers (SPIE) 8181, Earth Resources and Environmental Remote Sensing/GIS Applications II, 81811B October 26, 2011.* doi:10.1117/12.898230. Available from http://dx.doi.org/10.1117/12.898230 last accessed 6th November 2014.

Criado Boado, F. and Villoch Vasquez, B. 2000. Monumentalising landscape. From present perception to the past meaning of Galician megalithism (north-west Iberian peninsula). *EJA* 3: 188–216.

Cummings, V. 2000. Landscapes in motion: Interactive computer imagery and the Neolithic landscapes of the Outer Hebrides. In: Buck, C. Cummings, V. Henley, C. Mills, S. and Trick, S. (eds.) *Proceedings of the UK Chapter of Computer Applications and Quantitative Methods in Archaeology 1999.* BAR International Series 844. Oxford: Archaeopress. 11–20.

Cummings, V. 2002. Between mountains and sea. A reconsideration of the Neolithic monuments of south-west Scotland. *Proceedings of the Prehistoric Society* 68: 125–146.

Cummings, V. 2003. Building from memory: Remembering the past at Neolithic monuments in western Britain. In: H. Williams (ed.) *Archaeologies of Remembrance: Death and Memory in Past Societies.* New York and London: Kluwer Academic/Plenum Press. 25–43.

Cummings, V. 2008. Virtual reality, visual envelopes and characterising landscape. In: David B. and Thomas J. (eds.) *Handbook of Landscape Archaeology.* California: Left Coast Press. 285–290.

Cummings, V. and Whittle, A. 2003. Tombs with a view. Landscape, monuments and trees. *Antiquity* 77: 255–266.

Cummings, V. and Whittle, A. 2004. *Places of Special Virtue, Megaliths in the Neolithic landscape of Wales.* Oxford: Oxbow Books.

D’Agata, A. L. Van de Moortel, A. and Richardson, M. B. (eds.) 2009. *Archaeologies of Cult: Essays on Ritual and Cult in Crete. Hesperia* supplement 42. Athens. American School of Classical Studies.

Darnell, J. 2009. Iconographic attraction, iconographic syntax and tableaux of royal ritual power in the Pre- and Proto- Dynastic rock inscriptions of the Theban Western Desert. *Archéo-Nil* 19: 83–120.

Darnell, J. 2013. *Theban Desert Road Survey II: The Rock Shrine of Pahu, Gebel Akhenaton, and Other Rock Inscriptions from the Western Hinterland of Qamûla.* Yale Egyptological Publications 1. New Haven, CT: Yale Egyptological Institute.

Darnell, J. and Darnell, D. 1993. The Luxor-Farshut desert road project. *Oriental Institute Annual Reports 1992–1993.* 48–55. Available from http://oi.uchicago.edu/about/annual-reports/oriental-institute-1992-1993-annual-report last accessed 06 October 2014.

Darnell, J. and Darnell, D. 1994. The Luxor-Farshut desert road project. *Oriental Institute Annual Reports 1993–1994.* 40–43. Available from http://oi.uchicago.edu/sites/oi.uchicago.edu/files/uploads/shared/docs/ar/91-00/93-94/93-94_Desert_Road.pdf last accessed 06 October 2014.

Darnell, J. and Darnell, D. 2013. The Girga Road: Abu Ziyâr, Tundaba, and the integration of the southern oases into the Pharaonic state. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 221–264.

Darnell, J. and Manassa, C. 2006. *Yale Toshka Desert Survey I: Inscriptions of the 'Chephren Quarries' in the Nubian Western Desert.* Unpublished preliminary copy.

Darnell, J. and Manassa, C. 2013. A trustworthy seal-bearer on a mission: The monuments of Sabastet from the Khephren Diorite Quarries. In: H. Fischer-Elfert and R. B. Parkinson (eds.) *Studies on the Middle Kingdom in memory of Detlef Franke.* Philippika Marburger altertumskundliche Abhandlungen 41. Wiesbaden: Harrassowitz Verlag. 55–92.

Darnell, J. Darnell, D. Friedman, R. and Hendrickx, S. 2002. *Theban Desert Road Survey in the Egyptian Western Desert I: Rock Inscriptions at Gebel Tjauti and Wadi El-Hôl.* Oriental Institute Publications 119. Chicago: University of Chicago.

David, B. and Thomas, J. (eds.) 2008. *Handbook of Landscape Archaeology.* Walnut Creek, California: Left Coast Press.

David, R. A. 1973. *Religious Ritual at Abydos (c. 1300 B.C.).* Modern Egyptology Series. Warminster: Aris & Phillips.

DeBoer, W. 2004. Comment on Tilley (2004). *CAJ* 14: 199–201.

DMA. 1990. *Datums, Ellipsoids, Grids and Grid Reference Systems.* Defense Mapping Agency Technical Manual 8358.1. Available from http://earth-info.nga.mil/GandG/publications/tm8358.1/tr83581a.html#ZZ7, last accessed 04 July 2013.

DeLoach, S. R. and Leonard, J. 2000. Making photogrammetric history. *Professional Surveyor* 20: 6–10.

Digitalglobe. 2013a. *Quickbird Design and Specifications*. Dated 06/03/2013. Available from http://www.digitalglobe.com/resources/satellite-information, last accessed 12 November 2013.

Digitalglobe. 2013b. *Digitalglobe Imagery Products: Product Guide.* Dated 06/04/2013. Available from http://www.digitalglobe.com/resources/technical-information, last accessed 12 November 2013.

Doneus, M. and Briese, C. 2006a. Digital terrain modelling for archaeological interpretation within forested areas using full-waveform laserscanning. In: M. Ioanides, D. Arnold, F. Niccolucci, and K. Mania. (eds.) *The 7th Symposium on Virtual Reality, Archaeology and Intelligent Cultural Heritage VAST 2006.* Wellesley, MA: AK Peters.

Doneus, M. and Briese, C. 2006b. Full-waveform airborne laser scanning as a tool for archaeological reconnaissance. In: S. Campana and M. Forte, (eds.) *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology.* BAR International Series 1568. Oxford: Archaeopress. 99–106.

Donohue, V. A. 1992. The goddess of the Theban mountain. *Antiquity* 66: 871–885.

Dougherty, S. P. and Friedman, R. F. 2008. Sacred or mundane: Scalping and decapitation at Predynastic Hierakonpolis. In: Midant-Reynes, B. and Tristant, Y. (eds.) *Egypt at its Origins 2: proceedings of the international conference "Origin of the State. Predynastic and Early Dynastic Egypt", Toulouse (France), 5th-8th September 2005.* Leuven: Peeters and Departement Oosterse Studies. 311–338.

Doyle, J. A. Garrison, T. G. and Houston, S. D. 2012. Watchful realms: Integrating GIS analysis and political history in the southern Maya lowlands. *Antiquity* 86: 792–807.

Dreyer, G. 1986. *Elephantine VIII: Der Tempel der Satet.* DAIK 39. Mainz: Phillip von Zabern.

Edwards, I. E. S. 1993. *The Pyramids of Egypt. Revised Edition.* London: Penguin Books.

Eggermont, H. Verschuren, D. Fagot, M. Rumes, B. Van Bocxlaer B. and Kröpelin, S. 2008. Aquatic community response in a groundwater-fed desert lake to Holocene desiccation of the Sahara. *Quaternary Science Reviews* 27: 2411–2425.

Eichhorn, B. Hendricks, S. Riemer, H. and Stern, B. 2005. Desert roads and transport vessels from late Roman-Coptic times in the eastern Sahara. *Journal of African Archaeology* 3.2: 231–239.

Eichler, E. 1994. Zur Kultischen Bedeutung von Expeditionsinschriften. In: B. M. Bryan and D. Lorton (eds.) *Essays in Egyptology in Honour of Hans Goedicke.* San Antonio, Texas: Van Siden. 69–80.

Endruweit, A. 1994. *Städtischer Wohnbau in Ägypten: Klimagerechte Lehmarchitectur in Amarna*. Berlin: Gebr. Mann Verlag.

Engelbach, R. 1933. The quarries of the western Nubian desert: A preliminary report. *ASAE* 33: 65–74.

Engelbach, R. 1934. A foundation scene of the Second Dynasty. *JEA* 20: 183–184.

Engelbach, R. 1939. The quarries of the western Nubian desert and the ancient road to Tushka. *ASAE* 39: 369–390.

Espinel, A. D. 2005. A newly identified stela from Wadi el-Hudi (Cairo JE 86119). *JEA* 91: 56–70.

Etaya, M. Sudo, N. and Sakata, T. 2000. Detection of subsurface ancient Egyptian remains utilising optical and microwave satellite data. *Proceedings of the IGARSS 2000 Geoscience and Remote Sensing Symposium* 6: 2480–2482.

Eve, S. 2012. Augmenting phenomenology: Using augmented reality to aid archaeological phenomenology in the landscape. *JAMT* 19: 582–600.

Exon, S. Gaffney, V. Woodward, A. and Yorston, R. 2000. *Stonehenge Landscapes: Journeys through Real-and-Imagined Worlds.* Oxford: Oxbow.

Farr, T. G., Rosen, P. A. Caro, E. Crippen, R. Duren, R. Hensley, S. Kobrick, M. Paller, M. Rodriguez, E. Roth, L. Seal, D. Shaffer, S. Shimada, J. Umland, J. Werner, M. Oskin, M. Burbank, D. Alsdorf, D. 2007. *The Shuttle Radar Topography Mission.* Available from http://www2.jpl.nasa.gov/srtm/srtmBibliography.html, last accessed 18 July 2013.

Fakhry, A. 1952. *The Inscriptions of the Amethyst Quarries at Wadi el-Hudi.* Cairo.

Felleman, J. P. 1986. Landscape visibility. In: R.C. Smardon, J.F. Palmer, and J.P. Felleman (eds.) *Foundations for Visual Project Analysis*. New York: John Wiley and Sons. 47–62.

Fisher, P. F. 1991. First experiments in viewshed uncertainty: The accuracy of the viewshed area. *Photogrammetric Engineering and Remote Sensing* 57: 1321–1327.

Fisher, P. F. 1993. Algorithm and implementation uncertainty in viewshed analysis. *International Journal of Geographic Information Systems* 8: 331–347.

Fisher, P.F. 1994. Probable and fuzzy models of the viewshed operation. In: M. F. Warboys (ed.) *Innovations in GIS 1*. London: Taylor & Francis. 161–175.

Fitzjohn, M. 2007. Viewing places: GIS applications for the perception of space in the mountains of Sicily. *WA* 39.1: 36–50.

Fleming, A. 1999. Phenomenology and the megaliths of Wales. A dreaming too far? *Oxford Journal of Archaeology* 18: 119–125.

Fleming, A. 2005. Megaliths and post-modernism: The case of Wales. *Antiquity* 79: 921–932.

Fleming, A. 2006. Post-processual landscape archaeology: A critique. *CAJ* 16: 267–280.

Forbes, R. 1921. *The Secret of the Sahara: Kufara.* New York.

Förster, F. 2007. With donkeys, jars and water bags into the Libyan Desert: The Abu Ballas Trail in the late Old Kingdom/First Intermediate Period. *British Museum Studies in Ancient Egypt and Sudan* 7: 1–39.

Förster, F. 2013. Beyond Dakhla: The Abu Ballas trail in the Libyan Desert, (SW Egypt). In: F. Förster, and H. Riemer, (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Köln: Heinrich-Barth-Institut. 297–338.

Fowler, M. 1994. Ground cover mapping from multispectral satellite imagery. *Aerial Archaeology Research Group News* 9: 11–19.

Fowler, M. 1995. Detection of archaeological features on multispectral satellite imagery. *Archaeology Research Group News* 10: 7–14.

Fowler, M. 1996. High-resolution satellite imagery in archaeological application: A Russian satellite photograph of the Stonehenge region. *Antiquity* 70: 667–671.

Franke, D. 1994. *Das Heiligtum des Heqaib auf Elephantine.* Studien zur Archäologie und Geschichte Altägyptens 9. Heidelberg: Heidelberger Orientverlag.

Franklin, W. R. 2000. Applications of analytical cartography. *CGIS* 27: 225–237.

Fraser, D. 1983. *Land and Society in Neolithic Orkney.* BAR Series 117. Oxford: Archeopress.

Fraser, G. W. 1894. Hat-nub. *Proceedings of the Society of Biblical Archaeology* 16: 73–82.

Fully, G. 1956. Une nouvelle methode de determination de la Taille. *Annales de Medecine Legale*. 35.5: 266–273.

Frieman, C. and Gillings, M. 2007. Seeing is perceiving? *WA* 39.1: 4–16.

Gaffney, V. and Stancic, Z. 1991. *GIS Approaches to Regional Analysis: A Case Study of the Island of Hvar.* Ljublijana: Filozofska fakulteta.

Gaffney, V. and van Leusen, P. M. 1995. Postscript - GIS, environmental determinism and archaeology. In: Lock, G and Stancic, Z (eds.) *Archaeology and Geographical Information Systems*. London: Taylor & Francis. 367–382.

Gatsis, I. Pavlopoulos, A. and Parcharidis, I. 2001. Geomorphological observations and related natural hazards using merged remotely sensed data: A case study in the Corinthos Area (NE Peloponnese, S. Greece). *Geografiska Annaler. Series A. Physical Geography* 83.4: 217–228.

Garbuzov, G. P. 2003a. Archaeological Investigations and satellite remote sensing. *Rossiiskaia Arkheologiia* 2: 45–55.

Garbuzov, G. P. 2003b. The use of space remote sensing for archaeological mapping of the Tarman Peninsula, Russia. *Archaeologia Polona* 41: 176–7.

Garnett, A. 2013. Landscape is time materialising: A study of embodied experience and memory in Egypt’s eastern desert. In: A. M. Chadwick and C. D. Gibson (eds.) *Memory, Myth and Long-term Landscape Inhabitation.* Oxford: Oxbow Books. 226–239.

Gasse, A. 2012. Wadi Hammamat and the sea from the origins to the end of the New Kingdom. In: P. Tallet and El-Sayed Mahfouz (eds.) *The Red Sea in Pharaonic times:*

Recent Discoveries Along the Red Sea Coast. Proceedings of the Colloquium held in Cairo / Ayn Soukhna 11th–12th January 2009. IFAO 155. Cairo. 133–143.

Giddy, L. and Jeffreys, D. 1992. Memphis 1991. *JEA* 78: 1–11.

Gidlow, J. 2000. Archaeological computing and disciplinary theory. In G. Lock and K. Brown (eds.) *On the Theory and Practice of Archaeological Computing.* Oxford: Oxbow. 23–30.

Gillings, M. 2009. Visual affordance, landscape, and the megaliths of Alderney. *Oxford Journal of Archaeology* 28.4: 335–356.

Gillings, M. 2012. Landscape phenomenology, GIS and the role of affordance. *JAMT* 19: 601–611.

Gillings, M. and Goodrick, G. T. 1996. Sensuous and reflexive GIS: Exploring visualisation and VRML. *Internet Archaeology* 1. Available from http://intarch.ac.uk/journal/issue1/gillings_index.html, last accessed 24 February 2014.

Giveon, R. 1972. Le temple d'Hathor à Serabit el-Khadem. *Archéologia* 44: 64–69.

Giveon, R. 1974. Investigations in the Egyptian mining centres in Sinai. *Tel Aviv* 1: 100-108.

Giveon, R. 1976. Two Critical Notes Concerning Sinai. *GM* 20: 23–25

Giveon, R. 1978. 'Lady of the turquoise': Hathor at Serabit el Khadim and Timna. In: Giveon, R. *The impact of Egypt on Canaan: Iconographical and Related Studies.* Orbis Biblicus et Orientalis 20. Freiburg and Göttingen: Universitätsverlag; Vandenhoeck & Ruprecht. 61–67.

Goedicke, H. 1995. Giza: Causes and concepts. *Bulletin of the Australian Centre for Egyptology* 6: 31–51.

Golkhale, P and Bapat, S. 2006. Reconstructing the ancient republics (janapadas) of the Indian sub-continent. In: S. Campana and M. Forte, (eds.) *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology.* BAR International Series 1568. Oxford: Archaeopress. 227–234.

Goosens, R. and Van Ranst, E. 1998. The use of remote sensing to map gypsiferous soils in the Ismalia Province, (Egypt). *Geoderma* 87: 47–56.

Goucher, K. 1997. Hill of Tara topographical survey and mapping. In: C. Newman (ed.) *Tara: An Archaeological Survey.* Discovery Programme Monograph 2. Dublin. 245–252.

Graham, A. 2010. Islands in the Nile. In: M. Bietak, E. Czerny, and I. Forstner-Müller (eds.) *Cities and Urbanism in Ancient Egypt: Papers from a Workshop in November 2006 at the Austrian Academy of Sciences.* Wien: Verlag der Österreichischen Akademie der Wissenschaften. 125–143.

Graham, A. Strutt, K. D. Hunter, M. A. Jones, S. Masson, A. Millett, M and Pennington, B.T. 2012. Theban Harbours and Waterscapes Survey 2012. *JEA* 98: 27–42.

Grajetzski, W. 2010. Class and society: Position and possessions. In: W. Wendrich (ed.) *Egyptian Archaeology.* Wiley-Blackwell. 180–199.

Greene, T. 2007. *Diet and dental health in Predynastic Egypt: A comparison of Hierakonpolis and Naqada.* Saarbrüken: VDM Verlag.

Habachi, L. Haeny, G. and Junge, F. 1985. *Elephantine IV: The Sanctuary of Heqaib.* DAIK 33. Mainz: Phillip von Zabern.

Hageman, J. B. and Bennett, D. A. 2000. Construction of digital elevation models for archaeological applications. In: K. L. Wescott and R. J. Brandon (eds.) *Practical Applications of GIS for Archaeologists: A Predictive Modelling Kit.* London: Taylor and Francis. 113–127.

Haining, R. 2003. *Spatial Data Analysis: Theory and Practice.* Cambridge: Cambridge University Press.

Hamandawana, H. Eckardt, F. and Ringrose, S. 2007. Proposed methodology for georeferencing and mosaicking Corona photographs. *International Journal of Remote Sensing* 28.1: 5–22.

Hamilton, S. and Manley, J. 2001. Hillforts, monumentality and place: A chronological and topographic review of the first millennium BC hillforts of south-east England. *EJA* 4.1: 7–42.

Hamilton, S. Whitehouse, R. Brown, K. Combes, P. Herring, E. and Seager-Thomas, M. 2006. Phenomenology in practice: Towards a methodology for a ‘Subjective’ Approach. *EJA* 9.1: 31–71.

Harrell, J. A. 2002. Pharaonic stone quarries in Egyptian deserts. In: R. Friedman (ed.) *Egypt and Nubia: Gifts of the Desert.* London: British Museum Press. 232–243.

Harrell, J. A. 2006. Survey of ancient Egyptian stone quarries (rock varieties and images, locations, and ages). Toledo: University of Toledo, Ohio. Available from http://www.eeescience.utoledo.edu/Faculty/Harrell/Egypt/AGRG_Home.html, last accessed 24th May 2012.

Harrell, J. A. and Brown, V. M. 1994. Chephren’s Quarry in the Nubian desert of Egypt. *Nubica* 3.1: 43–57.

Harrell, J. A. and Brown, V. M. 1995. An Old Kingdom basalt quarry at Widan el-Faras and the quarry road to Lake Moeris in the Fayum, Egypt. *JARCE* 32: 71–91.

Harrell, J. A. and Storemyr, P. 2009. Ancient Egyptian quarries – an illustrated overview. In: N. Abu-Jaber, E. G. Bloxam, P. Degryse, and T. Heldal, (eds.) *QuarryScapes: Ancient Stone Quarry Landscapes in the Eastern Mediterranean* Oslo: NGU, Norges geologiske undersøkelse. 7–50.

Harrell, J. A. Brown, V. M. and Mahsoud, S. M. 2000. An Early Dynastic quarry for stone vessels at Gebel Manzal el-Seyl, Eastern Desert. *JEA* 86: 33–42.

Harrington, N. 2013. *Living with the Dead: Ancestor Worship and Mortuary Ritual in Ancient Egypt.* Oxford: Oxbow.

Hassan, F. A. 1996. Nile floods and political disorder in early Egypt. In: H. N. Dalfes, G. Kukla, and H. Weiss (eds.) *Third Millennium BC Climate Change and Old World Collapse.* NATO ASI Series 1: Global Environmental Change volume 49. Springer. 1–23.

Haynes, C. V. 1980. Geochronology of Wadi Tushka – Lost tributary of the Nile. *Science* 210: 68–71.

Haynes, C.V. 1987. Holocene migration rates of the Sudano-Sahelian wetting front, Arba'in desert, eastern Sahara. In: A.E. Close (ed.) *Prehistory of Arid North Africa.* Dallas: Southern Methodist University Press. 69–84.

Haynes, C.V. 2001. Geochronology and climate change of the Pleistocene—Holocene transition in the Darb el Arba'in desert, eastern Sahara. *Geoarchaeology* 16: 119–141.

Helck, W. 1989. Nochmals zur angeblichen Mitregentschaft Sesostris' I. mit seinem Vater Amenemhet I. *Orientalia* 58: 315–317.

Heldal, T. 2009. Constructing a quarry landscape from empirical data. General perspectives and a case study at the Aswan West Bank, Egypt. In: N. Abu-Jaber, E. G. Bloxam, P. Degryse, and T. Heldal, (eds.) *QuarryScapes: Ancient Stone Quarry Landscapes in the Eastern Mediterranean* Oslo: NGU, Norges geologiske undersøkelse. 125–154.

Heldal, T. Storemyr, P. Bloxam, E. Shaw, I. Lee, R. and Salem, A. 2009a. GPS and GIS methodology in the mapping of Chephren's quarry, Upper Egypt: A significant tool for documentation and interpretation of the site. In: Y. Maniatis, (ed.), *ASMOSIA VII: Actes du VIIe Colloque International de l'ASMOSIA Organisé par l'École Française d'Athènes, le National Center for Scientific Research, "Dimokritos", la 18e Éphorie des Antiquités Préhistoriques et Classiques (Kavala) et l'Institute of Geology and Mineral Exploration, Thasos, 15–20 Septembre 2003*. Athènes: École Française d'Athènes. 227–241.

Heldal, T. Bloxam, E. Degryse, P. Storemyr, P. and Kelany, A. 2009b. Gypsum quarries in the northern Faiyum quarry landscape, Egypt: A geo-archaeological case study. In: N. Abu-Jaber, E. G. Bloxam, P. Degryse, and T. Heldal, (eds.) *QuarryScapes: Ancient Stone Quarry Landscapes in the Eastern Mediterranean* Oslo: NGU, Norges geologiske undersøkelse. 51–66.

Hendrickx, S. Förster, F. and Eyckerman, M. 2013. The Pharaonic pottery of the Abu Ballas trail: 'Filling Stations' along a desert highway in southwestern Egypt. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 339–380.

Higuchi, T. 1983. *The Visual and Spatial Structure of Landscapes*. Cambridge, Massachusetts: MIT Press.

Hikade, T. 2006. Expeditions to the Wadi Hammamat during the New Kingdom. *JEA 92:* 153–168.

Hillier, J. K. Bunbury, J. M. and Graham, A. 2007. Monuments on a migrating Nile. *JAS* 34.7: 1011–1015.

Hodder, I. 1982. *The Present Past.* London: Batsford.

Hodder, I. 1992. *Theory and Practice in Archaeology.* London and New York: Routledge.

Hodder, I. and Hutson, S. 2003. *Reading the Past: Current Approaches to Interpretation in Archaeology 3rd Edition*. Cambridge: Cambridge University Press.

Hoelzmann, P. 2002. Lacustrine sediments as indicators of climate change during the Late Quaternary in western Nubia (eastern Sahara). In: Jennerstr. (ed.), *Tides of the desert—Gezeiten der Wüste. Contributions to the Archaeology and Environmental History of Africa in Honour of Rudolph Kuper*. Africa Praehistorica, 14. Köln: Heinrich-Barth-Institut. 375–388.

Hoelzmann, P. Keding, B. Berke, H. Kröpelin, S. and Kruse, H-J. 2000. Environmental change and archaeology: Lake evolution and human occupation in the eastern Sahara during the Holocene. *Palaeogeography, Palaeoclimatology, Palaeoecology* 169: 193–217.

Hoffmeier, J. K. and Moshier, S. O. 2013. ‘A highway out of Egypt’: The main road from Egypt to Canaan. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 485–510.

Hornung, E. 1982. *Conceptions of God in Ancient Egypt.* Trans. J. Baines. New York: Cornell University Press.

Hornung, E. 1992. *Idea Into Image: Essays on Ancient Egyptian Thought.* Trans. E. Bredeck. Timken Publishers.

Hritz, C. and Wilkinson, T. J. 2006. Using Shuttle Radar Topography to map ancient water channels in Mesopotamia. *Antiquity* 80: 415–424.

Humphrey, C. and Laidlaw, J. 1994. *The Archetypal Actions of Ritual: A Theory of Ritual Illustrated by the Jain Rite of Worship.* Oxford: Clarendon Press.

Husar, R. B. Husar, J. D. and Martin, L. 2000. Distribution of continental surface aerosol extinction based on visual range data. *Atmospheric Environment* 34: 5067–5078.

Ignacio, J. Fernández, F. Subias, E, and Cuesta, R. 2012. Deconstructing and reconstructing the landscape of Oxyrhynchus using textual sources, cartography, remote sensing and GIS. In: A. Chrysanthi, P. M. Flores, C. Papadopoulos (eds.) *Thinking Beyond the Tool: Archaeological Computing and the Interpretive Process.* BAR International Series 2344. Oxford: Archaeopress. 131–154.

Ikram, S. 1989. Domestic shrines and the cult of the royal family at el-Amarna. *JEA* 75: 89–101.

Ikram, S. Kaiser, J. and Walker, R. (eds.) 2014. *Egyptian Bioarchaeology: Humans, Animals, and the Environment.* Sidestone Press.

Ingold, T. 2005. Comments on Christopher Tilley, 'The Materiality of Stone: Explorations in Landscape Phenomenology.' *Norwegian Archaeological Review* 38: 122–129.

Insoll, T. 2004. *Archaeology, Ritual, Religion.* London and New York: Routledge.

Israelevitz, P. 2003. A fast algorithm for approximate viewshed computation. *Photogrammetric Engineering and Remote Sensing* 69: 767–774.

Iversen, E. 1984. The Inscription of Herwerre at Serabit - al - Kadem. In: C. Muller (ed.) *Studien zu Sprache und Religion Ägyptens zu Ehren von Wolfhart Westendorf.* Göttingen. 507–509.

Jaritz, H. 1981. Zum Heiligtum am Gebel Tingar. *MDAIK* 37: 241–246.

Jeffreys, D. G. 1996. House, palace and islands at Memphis. In: Bietak, M. (ed.) *Haus und Palast im Alten Ägypten*. Vienna. 287–294.

Jeffreys, D. G. 1998. The topography of Heliopolis and Memphis: Some cognitive aspects. In: H. Guksch and D. Polz (eds.) *Stationen: Beiträge zur Kulturgeschichte Ägyptens: Festschrift für Rainer Stadelmann zur Vollendung des 65. Lebensjahres.* Mainz: Phillip von Zabern. 63–71.

Jeffreys, D. G. 2010. Regionality, cultural and cultic landscapes. In: W. Wendrich (ed.) *Egyptian Archaeology.* Wiley-Blackwell. 102–118.

Jeffreys, D. and Tavares, A. 1994. The historic landscape of Early Dynastic Memphis. *MDAIK* 50: 143–173.

Jennings, J. and Craig, N. 2003. Using GIS for polity-wide analysis of Wari imperial political economy. *Journal of GIS in Archaeology* 1: 33–46.

Jensen, J. 1996. *Introductory Digital Image Processing: A Remote Sensing Perspective.* New York: Prentice Hall.

Jimenez Higueras, M. Á. 2012. Es posible reconstruir el paisaje de la necrópolis tebana? El caso de Dra Abu el-Naga. In: L. M. de Araújo and J. das Candeias Sales (eds.) *Novos trabalhos de Egiptologia Ibérica: IV Congresso Ibérico de Egiptologia - IV Congreso Ibérico de Egiptología 1*. Lisboa: Instituto Oriental e Centro de História da Facultade de Letras da Universidade de Lisboa. 535–553.

Johnson, M. H. 2006. On the nature of theoretical archaeology and archaeological theory. *Archaeological Dialogues* 13.2: 117–132.

Johnsen, H and Olsen, B. 1992. Hermeneutics and archaeology. On the philosophy of contextual archaeology. *AA* 57: 419–436.

Jones, A. 2002. *Archaeological Theory and Scientific Practice.* Cambridge.

Jones, E. and Pethen, H. 2012. Archaeological mapping and topographical survey. In: I. Shaw, (ed.) The Gurob Harem Palace Project, Spring 2012. *JEA* 98: 43–54.

Jones, E. and Pethen, H. In prep. Post-processing of the Dra Abu l'Naga differential GPS survey results.

Jones, M. 1995. A new Old Kingdom settlement near Ausim: Report of the archaeological discoveries made in the Barakat Drain improvement project. *MDAIK* 51: 85–98.

Jones, M. 1997. Archaeological discoveries in Doqqi and the course of the Nile at Cairo during the Roman period. *MDAIK* 53: 101–111.

Judd, M. 2006. Jebel Sahaba revisited. In: K. Kroeper, M. Chlodnicki, and M. Kobusiewicz (eds.) *Archaeology of early Northeastern Africa: In Memory of Lech Kryzaniak.* Poznan: Archaeological Museum. 153–166.

Kaczmarek, M. 2000. Anthropological analysis of mummified bodies from Saqqara. *Polish Archaeology in the Mediterranean* 11: 118–123.

Keating, R. 1975. *Nubian Rescue.* London: Robert Hale and Co.

Keita, S. O. Y. 2003. A study of vault porosities in early Upper Egypt from the Badarian through Dynasty I. *WA* 35.2: 210–222.

Keita, S. O. Y. and Boyce, A. J. 2006. Variation in porotic hyperostosis in the Royal Cemetery complex at Abydos, Upper Egypt: A social interpretation. *Antiquity* 80: 64–73.

Kelany, A. Negem, M. Tohami, A. and Heldal, T. 2009. Granite quarry survey in the Aswan region, Egypt: Shedding new light on ancient quarrying. In: N. Abu-Jaber, E. G. Bloxam, P. Degryse, and T. Heldal, (eds.) *QuarryScapes: Ancient Stone Quarry Landscapes in the Eastern Mediterranean* Oslo: NGU, Norges geologiske undersøkelse. 87–98.

Kemp, B. J. 1995. How Religious were the Ancient Egyptians? *CAJ* 5.1: 25–54.

Kemp, B. J. 2006. *Ancient Egypt: Anatomy of a Civilisation. 2nd Edition.* Routledge: London and New York.

Klemm, R. and Klemm, D. D. 2008. *Stones and Quarries in Ancient Egypt.* London: British Museum Press.

Klemm, D. D. Klemm, R. and Murr, A. 2002. Ancient gold mining in the eastern desert of Egypt and the Nubian desert of Sudan. In: R. Friedman (ed.) *Egypt and Nubia; Gifts of the Desert.* London: British Museum Press. 215–221.

Koschmieder, H. 1926. Theorie der horizontalen Sichtweite. *Beitsaege Physik zur Atmosphere* 12: 33–55.

Komatsu, G. Olsen, J. Ormö, J. di Achille, G. Kring, D. Matsui, T. 2006. The Tsenkher structure in the Gobi-Altai, Mongolia: Geomorphological hints of an impact origin. *Geomorphology* 74: 164–180.

Kouchoukos, N. 2001. Satellite images and Near Eastern landscapes. *Near Eastern Archaeology.* 64.1/2: 80–91.

Kröpelin, S. 1987. Palaeoclimatic evidence from early to mid-Holocene playas in the Gilf Kebir (Southwest Egypt). *Palaeoecology of Africa* 18: 189–208.

Kröpelin, S. Verschuren, D. Lézine, A.-M. Eggermont, H. Cocquyt, C. Francus, P. Cazet, J. –P. Fagot, M. Rumes, B. Russell, J. M. Darius, H. Schuster, M. von Suchodoletz and Engstrom, D. R. 2008. Climate-driven ecosystem succession in the Sahara: The past 6000 years. *Science* 320: 765–768.

Kuper, R. and Kröpelin, S. 2006. Climate-controlled Holocene occupation in the Sahara: Motor of Africa's evolution. *Science* 313: 803–807.

Kyriakidis, E. (ed.) 2007. *The Archaeology of Ritual.* Los Angeles: Cotsen Institute of Archaeology, University of California.

Ladefoged, T. N. McLachlan, S. M. Ross, S. C. L. Sheppard, P. J. and Sutton, D. G. 1995. GIS-based image enhancement of conductivity and magnetic susceptibility data from Ureturituri Pa and Fort Resolution, New Zealand. *AA* 60.3: 471–481.

Lake, M. 2007. Viewing space. *WA* 39.1: 1–3.

Lake, M. and Woodman, P. E. 2003. Visibility studies in archaeology: A review and case study. *Environment and Planning B: Planning and Design* 30: 389–707.

Lake, M. Woodman, P. E. and Mithen, S. J. 1998. Tailoring GIS software for archaeological applications: An example concerning viewshed analysis. *JAS* 25: 27–38.

Lasaponara, R. Masini, N. Holmgren, R. and Backe Forsberg, Y. 2012. Integration of aerial and satellite remote sensing for archaeological investigations: A case study of the Etruscan site of San Giovenale. *Journal of Geophysics and Engineering* 9: S26-S39.

Leclant, J. and Clerc, G. 1985. Fouilles et travaux en Égypte et au Sudan 1983–1984. *Orientalia* 54: 237–415.

Lehner, M. 1991. *Archaeology of an Image: The Great Sphinx at Giza.* Ph.D. dissertation, New Haven.

Lehner, M. 1997. *The Complete Pyramids.* London: Thames and Hudson.

Lesko, L. H. 1991. Ancient Egyptian Cosmogonies and Cosmology. In: B. Shafer (ed.) *Religion in Ancient Egypt.* London: Routledge. 88–122.

Letellier, B. 1977. Gründungszeremonien. In: W. Helck and E. Otto. (eds.) *LÄ II.* Wiesbaden: Otto Harrassowitz. 912–913.

Lillesand, R. Kiefer, R. and Chipman, J. 2004. *Remote Sensing and Image Interpretation.* New York: John Wiley and Sons.

Lloyd, A. B. 2013. Expeditions to the Wadi Hammamat: Context and concept. In: J. A. Hill, P. Jones, and A. J. Morales (eds.) *Experiencing Power, Generating Authority: Cosmos, Politics, and the Ideology of Kingship in Ancient Egypt and Mesopotamia*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology. 361–382.

Lloyd, C. D. and Atkinson, P. M. 2004. Archaeology and geostatistics. *JAS* 31: 151–164.

Llobera, M. 1996. Exploring the topography of mind: GIS, social space and archaeology. *Antiquity* 70: 612–622.

Llobera, M. 2006. What you see is what you get? Visualscapes, visual genesis and hierarchy. In: Evans, T. L. and Daly, P. (eds.) *Digital Archaeology: Bridging Method and Theory.* Routledge. 148–167.

Llobera, M. 2007a. Modeling visibility through vegetation. *International Journal of Geographic Information Science* 21.7: 799–810.

Llobera, M. 2007b. Reconstructing visual landscapes. *WA* 39.1: 59–69.

Llobera, M. 2012. Life on a pixel: Challenges in the development of digital methods within an “Interpretive” landscape archaeology framework. *JAMT* 19: 495–509.

Lock, G. R. and Harris, T. M. 1996. Danebury revisited: An English Iron Age hillfort in a digital landscape. In: M. Aldenderfer and H. D. G. Maschner (eds.) *Anthropology, Space and Geographic Information Systems.* Oxford: Oxford University Press. 214–240.

Loots, L. 1997. The use of projective and reflective viewsheds in the analysis of the Hellenistic city defence system at Sagalassos, Turkey. *Archaeological Computing Newsletter* 49: 12–16.

Love, S. H. 2004. *A Symbolic Landscape of Memphis: Landscape, Monuments, People and the Gods.* Unpublished MPhil dissertation; University College London.

Lovell, N. C. 1997. The 1995 excavations of the cemetery at Kafr Hassan Daoud, Wadi Tumilat. *Journal of the Society for the Study of Egyptian Antiquities* 27: 34–41.

Lundy, J. K. 1988. A report on the use of Fully's ‘Anatomical Method’ to estimate stature in military skeletal remains. *Journal of Forensic Sciences* 33.2: 534–539.

Macke, A. Macke-Ribet, C. and Connan, J. 2002. *Ta Set Neferou: Une Nécropole de Thèbes-Ouest et son Histoire V [Momification, chimie des baumes, anthropologie, paléopathologie].* Cairo: Der Namatallah Press.

Malm, W. 1999. *Introduction to Visibility.* Cooperative Institute for Research in the Atmosphere (CIRA) NPS Visibility Program Colorado State University. Available from United States Environmental Protection Agency website http://www.epa.gov/airquality/visibility/index.html, last accessed 25 March 2014.

Maniatis, Y. (ed.) 2009. *ASMOSIA VII: Actes du VIIe Colloque International de l'ASMOSIA organisé par l'École Française d'Athènes, the National Center for Scientific Research, "Dimokritos", la 18e Éphorie des Antiquités Préhistoriques et Classiques (Kavala) et l'Institute of Geology and Mineral Exploration, Thasos, 15–20 Septembre 2003.* Athènes: École Française d'Athènes.

Masali, M. 1972. Body size and proportions as revealed by bone measurements and their meaning in environmental adaptation. *Journal of Human Evolution* 1: 187–197.

Maschner, H. 1996. Geographic Information Systems in Archaeology. In: H. D. G. Maschner (ed.). *New Methods, Old Problems – Geographical Information Systems in Modern Archaeological Research.* Illinois: Southern Illinois University at Carbondale, occasional paper 23. 1–24.

Maxwell, T. A. Bahay Issawi, B. and Haynes Jr, V.C. 2010. Evidence for Pleistocene lakes in the Tushka region, south Egypt. *Geology* 38.12: 1135–1138.

McEwan, D. G. 2012. Qualitative landscape theories and archaeological predictive modelling — A journey through no man's land? *JAMT* 19: 526–547.

McEwan, D. G. and Millican, K. 2012. In search of the middle ground: Quantitative spatial techniques and experiential theory in archaeology. *JAMT* 19: 491–494.

McHugh, W. Breed, C. Schaber, G. McCauley, J. and Szabo B. 1988. Acheulian sites along the 'Radar rivers', southern Egyptian Sahara. *Journal of Field Archaeology* 15: 361–379.

McManus, K. Donoghue, D. Brooke, C. and Marsh, S. 2002. Airborne thermography of the vegetation-soil interface for detecting shallow ground disturbance. In: B. Warmbein (ed.) *Proceedings of the Conference Space Applications for Heritage Conservation.* European Space Agency: Strasbourg.

Meredith, D. 1952. The Roman remains in the eastern desert of Egypt I. *JEA* 38: 94–111.

Meredith, D. and Treganza, L. A. 1949. Notes on Roman roads and stations in the eastern desert. *Bulletin of the Faculty of Arts, Fouad I (now Cairo) University.* 11.1: 97–126.

Merola, P. Allegrini, A. Guglietta, D. and Sampieri, S. 2006. Using vegetation indices to study archaeological areas. In: S. Campana and M. Forte, (eds.) *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology.* BAR International Series 1568. Oxford: Archaeopress. 303–310.

Merwin, D. A. Cromley, R. G. and Civco, D. L. 2002. Artificial neural networks as a method of spatial interpolation for digital elevation models. *CGIS* 29: 99–110.

Meskell, L. 1996. The somatisation of archaeology. Institutions, discourses, corporeality. *Norwegian Archaeological Review* 29: 1–16.

Meskell, L. 1999. *Archaeologies of Social Life.* Malden: Blackwell.

Meskell, L. 2002. *Private Life in New Kingdom Egypt.* New Jersey: Princeton University Press.

Meskell, L. 2004. *Object Worlds in Ancient Egypt.* Oxford and New York: Berg.

Mey, P. Castel, G. and Goyon, J. C. 1980. Installations rupestres du Moyen et du Nouvel Empire au Gebel el-Zeit (près de Râs Dib) sur la Mer Rouge. *MDAIK* 36: 299–318.

Mills, A. J. 1968. The archaeological survey from Gemai to Dal – Report on the 1965–1966 Season. *Kush* 15: 200–210.

Mortensen, B. 1991. Change in the settlement pattern and population in the beginning of the historical period. *Ägypten und Levante* 2: 11–38.

Moser, C. and Feldman, C. (eds.) 2014. *Locating the Sacred: Theoretical Approaches to the Emplacement of Religion.* Oxford: Oxbow.

Moshier, S. and El-Kalani, A. 2008. Late Bronze Age paleogeography along the ancient Ways of Horus in Northwest Sinai, Egypt. *Geoarchaeology* 23.4: 450–473.

Mulhern, D. M. 2005. A probable case of gigantism in a Fifth Dynasty skeleton from the Western Cemetery at Giza, Egypt. *International Journal of Osteoarchaeology* 15: 261–275.

Mumford, G. and Parcak, S. H. 2002. Satellite imagery analysis and new fieldwork in South Sinai, Egypt (El-Markha Plain). *Antiquity* 76.4: 953–954.

Murnane, W. J. 1977. *Ancient Egyptian Co-regencies.* Chicago.

Murray, G. W. 1925. The Roman roads and stations in the eastern desert of Egypt. *JEA* 11: 138–150.

Murray, G. W. 1935. *Sons of Ishmael: A Study of the Egyptian Bedouin.* London.

Murray, G. W. 1939. The Road to Chephren's Quarries. *The Geographical Journal* 94.2: 97–114.

Naville, E. 1907. *The Temple of Deir el-Bahri V.* Egypt Exploration Society Memoirs 27. London. EES.

Naville, E. 1910. *The XIth Dynasty Temple at Deir el-Bahri II.* Egypt Exploration Society Memoirs 30. London. EES.

NGA. 2000. *Performance Specification Digital Terrain Elevation Data.* NGA Document MIL-PDF-89020B. Available from http://dds.cr.usgs.gov/srtm/version2_1/Documentation/, last accessed on 18th July 2013.

NGA. 2002. *Military Map Reading 201.* Guidance document, available from http://earth-info.nga.mil/GandG/coordsys/mmr201.pdf, last accessed 04 July 2013.

NGA. 2003. *SRTM Data Editing Rules.* NGA document Version 2.0 12th March 2003. Available from http://dds.cr.usgs.gov/srtm/version2_1/Documentation/, last accessed 18 July 2013.

Neumann, K. 1989. Holocene vegetation of the eastern Sahara: Charcoals from prehistoric sites. *African Archaeological Review* 7: 97–116.

O'Connor, D. 1985. The 'Cenotaphs' of the Middle Kingdom at Abydos. In: P. Posener – Kriéger (ed.) *Mélanges Gamal Eddin Mokhtar II.* Cairo: IFAO. 161–177.

O'Connor, D. 1992. The status of early Egyptian temples: An alternative theory. In: R. Friedman, and B. Adams (eds.) *The Followers of Horus: Studies Dedicated to Michael Allen Hoffman.* Oxbow Monograph 20. London: Oxbow Books.

Ogburn, D. E. 2006. Assessing the level of visibility of cultural objects in past landscapes *JAS* 33: 405–413.

Ogden, J. 2001. Metals. In: P. Nicholson and I. Shaw (eds.) *Ancient Egyptian Materials and Technologies.* Cambridge: Cambridge University Press.148–176.

Okin, G. Roberts, D. Murray, B. and Okin, W. 2001. Practical limits on hyperspectral vegetation discrimination in arid and semi-arid environments. *Remote Sensing of the Environment* 77.2: 212–225.

Osbourne, R. 2004. Hoards, votives, offerings: The archaeology of the dedicated object. *WA* 36.1: 1–10.

Ostir, K. and Nuninger, L. 2006. Paleorelief decoration and modelling: A case study in eastern Languedoc (France). In: S. Campana and M. Forte, (eds.) *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology.* BAR International Series 1568. Oxford: Archaeopress. 255–260.

Parcak, S. H. 2003. New methods for archaeological site detection via satellite image analysis: Case studies from Sinai and the Delta. *Archaeologia Polonia* 41: 243–245.

Parcak, S. H. 2004a. Egypt's Old Kingdom 'Empire'(?): A case study focusing on South Sinai. In: A. Hirsch and G. Knoppers (eds.) *Egypt, Israel and the Ancient Mediterranean World: Studies in Honour of Donal B. Redford.* Leiden: Brill.

Parcak, S. H. 2004b. Satellite remote sensing resources for Egyptology. *GM* 198: 63–78.

Parcak, S. H. 2007a. Towards a satellite remote sensing methodology for monitoring archaeological tell sites under threat in the Middle East. *Journal of Field Archaeology* 32.1: 65–81.

Parcak, S. H. 2007b. The Middle Egypt Survey Project: 2005/6 season report. *JEA* 92: 3–8.

Parcak, S. H. 2009. *Satellite Remote Sensing for Archaeology.* Abingdon and New York: Routledge.

Parcak, S. H. 2010. Pushing the envelope for satellite archaeology in Egypt: Quickbird feature detection, predictive site modelling and thermal site signatures. In: Campana, S. Forte, M. and Liuzza, C. (eds.) *Space, Time, Place: Third International Conference on Remote Sensing in Archaeology.* BAR International Series 2118. Oxford: Archaeopress.17–24.

Patterson, J. 2008. Late Holocene land use in the Nutzotin mountains: Lithic scatters, viewsheds, and resource distribution. *Arctic Anthropology* 44.2: 114–127.

Peterman, G. L. 1992. Geographic information systems: Archaeology's latest tool. *The Biblical Archaeologist* 55.3: 162–7.

Peterson, R. 2003. William Stukeley: An eighteenth century phenomenologist? *Antiquity* 77: 394–400.

Pethen, H. 2006. *Royal power, personal gain and the mythology of mineral extraction at Stelae Ridge, Gebel el-Asr, Lower Nubia.* Unpublished MA dissertation. University of Liverpool.

Pethen, H. 2012. The old and the new in Egyptian archaeology: Interpreting GIS data using textual evidence. In: A. Chrysanthi, P. M. Flores, C. Papadopoulos (eds.) *Thinking Beyond the Tool: Archaeological Computing and the Interpretive Process.* BAR International Series 2344. Oxford: Archaeopress. 103–122.

Pethen, H. 2014. The Pharaoh as Horus: Three dimensional falcon figures from mining sites, and the religious context for the extraction of minerals in the Middle Kingdom. In: Anonymous (ed.) *Cult and Belief in Ancient Egypt: Proceedings of the Fourth International Conference for Young Egyptologists 25-27 September 2012, Sofia.* Bulgarian Institute of Egyptology. 151–162.

Petrie, W. M. F. 1894. *Tell el-Amarna.* London: Egypt Exploration Society.

Petrie, W. M. F. 1906. *Researches in Sinai.* London: Egypt Exploration Society.

Phillip, G. Donoghue, D. Beck, A. and Galiatsatos, N. 2002. CORONA satellite photography: An archaeological application from the Middle East. *Antiquity* 76: 109–118.

Pinch, G. 1993. *Votive Offerings to Hathor.* Oxford: Griffith Institute.

Pinch, G. 1994. *Magic in Ancient Egypt*. London: British Museum Press.

Piombino-Mascali, D. McKnight, L. Snitkuviene, A. Jankauskas, R. Tamošiūnas, A. Valančius, R. Rosendahl, W. and Panzer, S. 2014. From Egypt to Lithuania: Marija Rudzinskaite-Arcimavičiene's mummy and its radiological investigation. In: Ikram, S. Kaiser, J. and Walker, R. (eds.) 2014. *Egyptian Bioarchaeology: Humans, Animals, and the Environment.* Sidestone Press.95–104.

Pirelli, R. 2007. Two new stelae from Mersa Gawasis. *Revue d'Égyptologie* 58: 100–104.

Quirke, S. 2001. *The Cult of Ra: Sun-worship in Ancient Egypt.* London: Thames and Hudson.

Raven, M. J. van Walsem, R. Aston, B. G. and Strouhal, E. 2001a. Preliminary report on the Leiden excavations at Saqqara, season 2001: The tomb of Meryneith. *Jaarbericht van het Vooraziatisch-Egyptisch Genootschap Ex Oriente Lux* 37: 71–89.

Raven, M. J. van Walsem, R. Aston, B. G. and Strouhal, E. 2001b. Preliminary report on the Leiden excavations at Saqqara, season 2002: The tomb of Meryneith. *Jaarbericht van het Vooraziatisch-Egyptisch Genootschap Ex Oriente Lux* 37: 92–109.

Raven, M. J. 2005. Egyptian concepts on the orientations of the human body. *JEA* 91: 37–54.

Raxter, M. H. Ruff, C. B. Azab, A. Erfan, M. Soliman, M. El-Sawaf, A. 2008. Stature estimation in ancient Egyptians: A new technique based on anatomical reconstruction of stature. *American Journal of Physical Anthropology* 136: 147–155.

Redford, S. 1996. Preliminary report on the work in the tomb of Parennefer – TT.188. *Memnonia* 7: 227–234.

Reeves, N. and Wilkinson, R. H. 1996. *The Complete Valley of the Kings.* London: Thames and Hudson.

Régen I. and Soukiassian G. 2008. *Gebel el-Zeit 2: Le Matériel Inscrit*. FIFAO 57. Cairo: IFAO.

Renfrew, C. 1985. *The Archaeology of Cult: The Sanctuary at Phylakopi.* British School of Archaeology at Athens. London and Athens: Thames and Hudson.

Renfrew, C. 1994a. Towards a Cognitive Archaeology. In: C. Renfrew and E. B. W. Zubrow (eds.) *The Ancient Mind: Elements of Cognitive Archaeology.* Cambridge: Cambridge University Press. 3–12.

Renfrew, C. 1994b. The archaeology of religion. In: C. Renfrew and E. B. W. Zubrow (eds.) *The Ancient Mind: Elements of Cognitive Archaeology.* Cambridge: Cambridge University Press. 47–54.

Rennell, R. 2012. Landscape, experience and GIS: Exploring the potential for methodological dialogue. *JAMT* 19: 510–525.

Reymond, E. A. E. 1969. *The Mythical Origin of the Egyptian Temple.* Manchester.

Richards, J. E. 1999. Conceptual Landscapes in the Egyptian Nile Valley. In: W. Ashmore and B. Knapp (eds.) *Archaeologies of Landscape: Contemporary Perspectives.* Malden, MA and Oxford: Blackwell. 83–100.

Richards, J. E. 2005. *Society and Death in Ancient Egypt: Mortuary Landscapes of the Middle Kingdom*. Cambridge: Cambridge University Press.

Riemer, H. 2013. Lessons in landscape learning: The dawn of long-distance travel and navigation in Egypt's Western Desert from prehistoric to Old Kingdom times. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 77–106.

Riemer, H. and Förster, F. 2013. Ancient desert roads: A new field of archaeological research. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 19–58.

Ritner, R. K. 1992. Egyptian magic: Questions of legitimacy, religious orthodoxy, and social deviance. In: A. B. Lloyd (ed.) *Studies in Pharaonic Religion and Society In Honour of J. Gwyn Griffiths.* Egypt Exploration Society, Occasional Publications 8. London.

Robins, G. 1983. Natural and canonical proportions in ancient Egyptians. *GM* 61: 17–25.

Robins, G. 2010. Space and movement in pre-Amarna Eighteenth Dynasty Theban tomb chapels. In: A. Woods, A. McFarlane, and S. Binder (eds.) *Egyptian Culture* *and Society: Studies in Honour of Naguib Kanawati 2.* Supplément aux ASAE 38. Publications du Conseil Suprême des Antiquités de l'Égypte: Cairo. 129–142.

Robins, G. and Shute C. C. D. 1983. The physical proportions and living stature of New Kingdom Pharaohs. *Journal of Human Evolution* 12: 455–465.

Robins, G. and Shute C. C. D. 1986. Predynastic Egyptian stature and physical proportions. *Human Evolution* 1.4: 313–324.

Rodriguez, E. Morris, C. S. Belz, J. E. Chapin, E. C. Martin, J. M. Daffer, W. and Hensley, S. 2005. *An Assessment of the SRTM Topographic Products.* Jet Propulsion Laboratory Technical Report D-31639. Jet Propulsion Laboratory Pasadena California. Available from http://www2.jpl.nasa.gov/srtm/srtmBibliography.html, last accessed 18th July 2013.

Rohl, D. 2000. *The Followers of Horus: Eastern Desert Survey Report, 1.* Basingstoke: Institute for the Study of Interdisciplinary Sciences.

Rose, J. C. 2006. Palaeopathology of the commoners at Tell Amarna, Egypt, Akhenaten's capital city. *Memórias do Instituto Oswaldo Cruz* 101.2: 73–76.

Rose, P. 1996. *Qasr Ibrim: The Hinterland Survey.* London: Egypt Exploration Society.

Rossi, C. and Ikram, S. 2013. Evidence of desert routes across northern Kharga (Egypt's Western Desert). In: F. Förster, and H. Riemer, (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Köln: Heinrich-Barth-Institut. 265–282.

Rothenberg, B. 1987. Pharaonic copper mines in south Sinai. *Newsletter of the Institute of Archaeo-metallurgical Studies* 10.11: 3–7.

Rothenberg, B. 1988. *The Egyptian Mining Temple at Timna.* London.

Rowe, A. 1939. Provisional notes on the Old Kingdom inscriptions from the Diorite Quarries. *ASAE* 38: 391–396.

Rowlands, A. Sarris, A. and Bell, J. 2006. Airborne multi-sensor remote sensing of exposed and subsurface archaeological remains at Itanos and Roussolakkos, Crete. In: S. Campana and M. Forte, (eds.) *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology.* BAR International Series 1568. Oxford: Archaeopress. 113–116.

Rundle-Clark, R. T. 1959. *Myth and Symbol in Ancient Egypt.* London: Thames and Hudson.

Ruggles, C. L. N. Medyckyj-Scott, D. J. and Gruffydd, A. 1993. Multiple viewshed analysis using GIS and its archaeological application: A case study in northern Mull. In: J. Andresen, T. Madsen and I. Scollar (eds.) *Computing the Past: Computer Applications and Quantitative Methods in Archaeology – CAA92.* Aarhus: Aarhus University Press. 125–132.

Sadek, A. I. 1980. *The Amethyst Mining Inscriptions of the Wadi el-Hudi.* Warminster.

Sadek, A. I. 1988. *Popular Religion in Egypt during the New Kingdom.* Hildesheimer Ägyptologische Beiträge 27.

Said, R. 1993. *The River Nile. Geology, Hydrology and Utilization*. Oxford - New York: Pergamon Press.

Saleh, A. A. 1969. The so-called 'primeval hill' and other related elevations in ancient Egyptian mythology. *MDAIK* 25: 110–120.

Schiffmann, H. R. 2001. *Sensation and Perception: An integrated approach. 5th Edition*. New York: Wily and Sons.

Schild, R. and Wendorf, F. 2001a. The Combined Prehistoric Expedition Results of the 2001 Season. *ARCE Bulletin* 180:16–17.

Schild, R. and Wendorf, F. 2001b. Geoarchaeology of the Holocene climatic optimum at Nabta Playa. *Geoarchaeology* 16: 8–28.

Schild, R. and Wendorf, F. 2013. Early and mid-Holocene palaeoclimates in the south- western desert of Egypt – The world before unification. *Studia Quaternaria* 30.2: 125–133.

Seidlmayer, S.J. 1996. Town and state in the early Old Kingdom. A view from Elephantine. In: J. Spencer (ed.) *Aspects of early Egypt.* London: British Museum Press. 108–127.

Seyfried, K. J. 1982. *Beiträge zu den Expeditionen des Mittleren Reiches in die Ost-Wüste.* Hildesheimer Ägyptologische Beiträge 15. Hildesheim.

Shafer, B. E. 1997. Temples, priests and rituals: An overview. In: B. E. Shafer (ed.) *Temples of Ancient Egypt.* Cornell University Press. 1–29.

Shanks, M. and Tilley, C. 1992. *Re-Constructing Archaeology. 2nd Edition. Routledge.*

Shaw, I. 1986. Survey at Hatnub. In: B. J. Kemp (ed.) *Amarna Reports III.* Egypt Exploration Society Occasional Publications 4. London. 189–212.

Shaw, I. 1994. Pharaonic quarrying and mining: Settlement and procurement in Egypt's marginal regions. *Antiquity* 68: 108–119.

Shaw, I. 1998. Exploiting the desert frontier: The logistics and politics of ancient Egyptian mining expeditions. In: A.B. Knapp (ed.) *Social Approaches to an Industrial Past: The Archaeology and Anthropology of Mining.* London: Routledge. 242–258.

Shaw, I. 2000a. Khafra's quarries in the Sahara. *EA* 16: 28–30.

Shaw, I. 2000b. The evidence for amethyst mining in Nubia and Egypt. In: L. Krzyzaniak, K. Kroeper and M. Kobusiewicz (eds.) *Recent Research into the Stone Age of Northeastern Africa, Studies in African Archaeology 7.* Poznan: Poznan Archaeological Museum. 219–227.

Shaw, I. (ed.) 2000c. *The Oxford History of Ancient Egypt.* Oxford and New York: Oxford University Press.

Shaw, I. 2002. Life on the edge: Gemstones, politics and stress in the deserts of Egypt and Nubia. In: R. Friedman (ed.) *Egypt and Nubia: Gifts of the Desert.* London: British Museum Press. 244–251.

Shaw, I. 2003. New Fieldwork at Gebel el-Asr: 'Chephren's Diorite Quarries'. In: Z. Hawass and L. Pinch-Brock (eds.) *Egyptology at the Dawn of the Twenty First Century: Proceedings of the Eighth International Congress of Egyptology I.* Cairo and New York: American University in Cairo Press. 448–454.

Shaw, I. 2006. 'Master of the Roads': Quarrying and communications networks in Egypt and Nubia. In: B. Mathieu, D. Meeks and M. Wissa (eds.) *L'Apport de l'Egypte à l'Histoire des Techniques: Méthodes, Chronologie et Comparaisons*. Cairo. IFAO. 253–266.

Shaw, I. 2007. Gold and amethyst mining at the Lower Nubian site of Wadi el-Hudi in the Roman period. In: T. Schneider and K. Szpakowska (eds.) *Egyptian Stories: A British Egyptological Tribute to Alan B. Lloyd on the Occasion of His Retirement*. Alter Orient und Altes Testament 347. Münster: Ugarit-Verlag. 319–328.

Shaw, I. 2010. *Hatnub: Quarrying Travertine in Ancient Egypt.* Egypt Exploration Society Memoir 88: London.

Shaw, I. 2013. 'We went forth to the desert land . . .' Retracing the routes between the Nile valley and the Hatnub travertine quarries. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 521–532.

Shaw, I. and Bloxam E. 1999. Survey and excavation at the ancient Pharaonic gneiss quarrying site of Gebel el-Asr, Lower Nubia. *Sudan and Nubia* 3: 13–20.

Shaw, I. and Heldal, T. 2003. Rescue work in the Khafra quarries at Gebel el-Asr. *EA* 23: 14–16.

Shaw, I. and Jameson, R. 1993. Amethyst mining in the eastern desert: A preliminary survey at Wadi el-Hudi. *JEA* 79: 81–97.

Shaw, I. Bloxam, E. Bunbury, J. Lee, R. Graham, A. and Darnell, D. 2001. Survey and excavation at the Gebel el-Asr gneiss and quartz quarries in Lower Nubia (1997–2000). *Antiquity* 75: 33–34.

Shaw, I. Bloxam, E. Bunbury, J. Lee, R. Graham, A. and Darnell, D. 2004. *Chephren's Gneiss Quarries: Three Seasons of Survey and Excavation at Gebel El-Asr, Lower Nubia.* Unpublished interim report.

Shaw, I. Bloxam, E. Heldal, T. and Storemyr, P. 2010. Quarrying and landscape at Gebel el-Asr in the Old and Middle Kingdoms. In: F. Raffaele, M. Nuzzolo and I. Incordino (eds.) *Recent Discoveries and Latest Researches in Egyptology: Proceedings of the First Neapolitan Congress of Egyptology, Naples, June 18–20 2008.* Wiesbaden: Harrassowitz-Verlag. 293–312.

Shaw, I, Jameson, R. and Bunbury, J. 1999. Emerald mining in Roman and Byzantine Egypt. *Journal of Roman Archaeology* 12: 203–215.

Sidebotham, S. E. Zitterkopf, R. E. and Riley, J. A. 1991. Survey of the Abu-Sha'ar–Nile road. *AJA* 95: 571–622.

Simpson, W. K. 1956. The single-dated monuments of Sesostris I: An aspect of the institution of co-regency in the Twelfth Dynasty. *JNES* 15: 214–19.

Simpson, W. K. 1958. A Hatnub stela of the early Twelfth Dynasty. *MDAIK* 16: 298–309.

Simpson, W. K. 1961. An additional fragment of a 'Hatnub' stela. *JNES* 20: 25–30.

Simpson, W. K. 1963. *Heka-Nefer and the Dynastic Material from Toshka and Arminna.* Publications of the Pennsylvania – Yale Expedition to Egypt, I. New Haven and Philadelphia.

Simpson, W. K. 1974. *The Terrace of the Great God at Abydos.* Publications of the Pennsylvania – Yale Expedition to Egypt 5. New Haven and Philadelphia.

Simpson, W. K. 1980. "Kenotaph" In. W. Helck, E. Otto and Westendorf (eds.) *LÄ III.* Wiesbaden: Otto Harrassowitz. 387–391.

Śliwa, J. 1992a. Siedlung des Mittleren Reiches bei Qasr el-Sagha. In: Anonymous (ed.) *Sesto Congresso Internazionale di Egittologia, Atti 1*. Torino: International Association of Egyptologists. 565–571.

Śliwa, J. 1992b. The Middle Kingdom settlement at Qasr el-Sagha, 1979-1988. *Studies in Ancient Art and Civilization* 5:19–38.

Śliwa, J. 2005. Der xnrt von Qasr el-Sagha. In: P. Jánosi, (ed.) *Structure and Significance: Thoughts on Ancient Egyptian Architecture*. Wien: Verlag der Österreichischen Akademie der Wissenschaften. 477–483.

Snape, S. 2013. A stroll along the corniche? Coastal routes between the Nile Delta and Cyrenaica in the Late Bronze Age. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 439–454.

Snape, S. and Wilson, P. 2007. *Zawiyet Umm el-Rakham I: The Temple and the Chapels.* Bolton: Rutherford.

Somaglino, C. and Tallet, P. 2013. A road to the Arabian Peninsula in the reign of Ramesses III. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 511–520.

Spence, K. 2007. A contextual approach to ancient Egyptian domestic cult. In: D. Barrowclough and C. Malone. (eds.) 2007. *Cult in Context: Reconsidering Ritual in Archaeology.* Oxford: Oxbow Books. 285–292.

Stevens, A. 2003. The material evidence for domestic religion at Amarna and preliminary remarks on its interpretation. *JEA* 89: 143–168.

Stevens, A. 2006. *Private Religion at Amarna: The Material Evidence.* BAR International Series 1587. Oxford: Archaeopress.

Stevens, A. 2011. Egypt. In: T. Insoll (ed.) *The Oxford Handbook of The Archaeology of Ritual and Religion.* Oxford University Press: Oxford. 722–744.

Stewart, D. 2001. New tricks with old maps: Urban landscape change, GIS and historic preservation in the less developed world. *The Professional Geographer* 55.3: 361–373.

Storemyr, P. 2009. Whatever else happened to the ancient Egyptian quarries? An essay on their destiny in modern times. In: N. Abu-Jaber, E. G. Bloxam, P. Degryse, and T. Heldal, (eds.) 2009. *QuarryScapes: Ancient Stone Quarry Landscapes in the Eastern Mediterranean* Oslo: NGU, Norges geologiske undersøkelse. 105–124.

Storemyr, P. Bloxam, E. Heldal, T and Salem, A. 2002. Survey at Chephren's Quarry, Gebel el-Asr, Lower Nubia: 2002. *Sudan and Nubia* 6: 25–29.

Storemyr, P. Bloxam, E. Heldal, T. and Kelany, A. 2013. Ancient desert and quarry roads on the west bank of the Nile in the First Cataract region. In: F. Förster and H. Riemer (eds.) *Desert Road Archaeology in Ancient Egypt and Beyond.* Africa Praehistorica 27. Institut für Ur- und Frühgeschichte der Universität zu Köln Forschungsstelle Afrika. 399–424.

Strouhal, E. 1995. Revealing the sufferings of the ancient Egyptians. *EA* 6: 11–13.

Strouhal, E. Němečková, A. and Kouba, M. 2003. Palaeopathology of Iufaa and other persons found beside his shaft tomb at Abusir (Egypt). *International Journal of Osteoarchaeology* 13.6: 331–338.

Strudwick, N. 2005. Theban tomb 99 (Senneferi): University of Cambridge Theban mission 2002. *ASAE* 79: 157–164.

Supernant, K. 2014. Intervisibility and intravisibility of rock feature sites: A method for testing viewshed within and outside the socio-spatial system of the Lower Fraser River Canyon, British Columbia. *JAS* 50: 497–511.

Tanner, R. 1974. Bemerkungen zur Sukzession der Pharaonen in der 12, 17 und 18 Dynastie. *ZÄS* 101: 121–129.

Tarlow, S. 2000. Emotion in Archaeology. *Current Anthropology* 41: 713–746.

Teeter, E. 2011. *Religion and Ritual in Ancient Egypt.* Cambridge: Cambridge University Press.

Tachikawa, T. Hato, M. Kaku, M. and Iwasaki. A. 2011a. *Characteristics of ASTER GDEM Version 2.* Presentation at the Institute of Electrical and Electronics Engineers' International Geoscience and Remote Sensing Symposium in Vancouver, Canada on 28th July. Available from https://lpdaac.usgs.gov/products/aster_products_table/astgtm, last accessed 30th April 2013.

Tachikawa, T. Kaku, M. Iwasaki. A, Gesch, D. Oimoen, M. Zhang, Z. Danielson, J. Krieger, T. Curtis, B. Haase, J. Abrams, M. Crippen, R. and Carabajal. C. 2011b.

ASTER Global Digital Elevation Model Version 2 – Summary of Validation Results. Compiled by Dave Meyer on behalf of the NASA Land Processes Distributed Active Archive Center and the Joint Japan-US ASTER Science Team. Published as ASTER GDEM Version 2 Validation Summary on https://lpdaac.usgs.gov/products/aster_products_table/astgtm, last accessed 30th April 2013.

Thomas, J. 1995. The politics of vision and the archaeologies of landscape. In. B. Bender (ed.) *Landscape, Politics and Perspectives*. Providence RI and Oxford: Berg. 48–49.

Thomas, J. 1996. *Time, Culture and Identity.* London: Routledge.

Thomas, J. 2001. Archaeologies of Place and Landscape. In: I. Hodder (ed.) *Archaeological Theory Today.* London: Blackwell. 165–186.

Thomas, J. 2004. *Archaeology and Modernity.* London and New York: Routledge.

Thomas, J. 2008. Archaeology, landscape and dwelling. In: David B. and Thomas J. (eds.) *Handbook of Landscape Archaeology.* California: Left Coast Press. 300–306.

Thomas, R. E. Wolff, E. W. Mulvaney, R. Steffensen, J. P. Johnsen, S. J. Arrowsmith, C. White, J. W. C. Vaughn, B. Popp, T. 2007. The 8.2ka event from Green land ice cores. *Quaternary Science Reviews* 26: 70–81.

Thompson, J. L. and Madden, G. M. 2006. Skeletal biology of Neolithic human remains from Dakhleh Oasis, Egypt. In: K. Kroeper, M. Chlodnicki, and M. Kobusiewicz (eds.) *Archaeology of early Northeastern Africa: In memory of Lech Kryzaniak.* Poznan: Archaeological Museum. 527–538.

Tilley, C. 1994. *A Phenomenology of Landscape.* Oxford: Berg.

Tilley, C. 2004a. *The Materiality of Stone. Explorations in Landscape Phenomenology.* Oxford.

Tilley, C. 2004b. Round barrows and dykes as landscape metaphors. *CAJ* 14: 185–203.

Tilley, C. 2008a. *Body and Image: Explorations in Landscape Phenomenology 2.* Walnut Creek California: Left Coast Press.

Tilley, C. 2008b. Phenomenological approaches to landscape archaeology. In: David B. and Thomas J. (eds.) *Handbook of Landscape Archaeology.* California: Left Coast Press. 271–284.

Timme, P. 1917. *Tell el Amarna vor der Deutschen Ausgrabung im Jahre 1911.* Berlin: Wissenschaftliche Veröffentlichungen der Deutschen Orient-Gesellschaft.

Trigger, B. G. 1996. Toshka and Arminna in the New Kingdom. In: P. Der Manuelian (ed.) *Studies in Honour of William Kelly Simpson.* Boston: Museum of Fine Arts. 801–810.

Trigger, B. G. Kemp, B. J. O'Connor, D. and Lloyd, A. 1983. *Ancient Egypt: A Social History.* Cambridge: Cambridge University Press.

Tschan, A. P. Raczkowski, W. and Latalowa, M. 2000. Perception and viewsheds: Are they mutually exclusive? In: Lock, G. (ed.) *Beyond the Map.* Amsterdam. 28–48.

Uphill, E. 2001. The question of Pharaonic co-regency. *Discussions in Egyptology* 49: 81–94.

Ur, J. 2003. CORONA satellite photography and ancient road networks: A northern Mesopotamian case study. *Antiquity* 77: 102–116.

Ur, J. 2005. Sennacherib's northern Assyrian canals: New insights from satellite imagery and aerial photography. *Iraq* 67: 317–345.

Valbelle, D. 1998. Les dieux Égyptiens et la rayauté au Sinaï. In: D. Valbelle and C. Bonnet (eds.) *Le Sinai Durant l'Antiquité et le Moyen Age: 4000 ans d'Histoire pour un Désert.* Paris: Editions Errance. 50–55.

Valbelle, D. and Bonnet, C. 1996. *Le Sanctuaire d'Hathor Maîtresse de la Turquoise.* Paris: Picard Editeur.

Van Haarlem, W. M. 1995. Temple Deposits at Tell Ibrahim Awad – A preliminary report. *GM* 148: 45–47.

Van Haarlem, W. M. 1996. Temple Deposits at Tell Ibrahim Awad II – An Update. *GM* 154: 31–32.

Van Haarlem, W.M. 2003. The excavations at Tell Ibrahim Awad (Sharqiya Province) seasons 1995 – 2000. In: Z. Hawass and L. Pinch – Brock (eds.) *Egyptology at the Dawn of the Twenty First Century: Proceedings of the Eighth International Congress of Egyptology I.* Cairo and New York: American University in Cairo Press. 536–540.

Van Haarlem, W. M. 2009. *Temple Deposits at Tell Ibrahim Awad.* Amsterdam.

Van Leusen, M. 1993. Cartographic modelling in a cell-based GIS, In: J. Andrensen, T. Madsen and I. Scollar (eds.) *Computing the Past: Computer Application and Quantitative Methods in Archaeology CAA92.* Aarhus: Aarhus University Press. 105–123.

Van Siclen, C. C. 1982. *The Chapel of Sesostris III at Uronarti.* San Antonio, Texas: Van Siclen.

Verhoeven, N. 2011. The many dimensions of ritual. In: T. Insoll (ed.) *The Oxford Handbook of the Archaeology of Ritual and Religion.* Oxford. Oxford University Press. 115–132.

Voigtmann, A. Becker, L and Hinrichs, K. 1997. A hierarchical model for multiresolution surface construction. *Graphical Models and Image Processing* 59.5: 333–348.

Watson, R. A. 1990. Ozymandias King of Kings: Post-processual radical archaeology as critique. *American Anthropology.* 92: 613–629.

Wegner, J. 2007. Reopening the tomb of Senusret III at Abydos. *EA* 30: 37–40.

Wegner, J. 2010. Tradition and innovation: The Middle Kingdom. In: W. Wendrich (ed.) *Egyptian Archaeology.* Wiley-Blackwell.119–142.

Weigall, A. 1907. *A Report on the Antiquities of Lower Nubia (The first cataract to the Sudan frontier) and their Condition in 1906-7.* Oxford: Oxford University Press.

Weigall, A. 1909. *Travels in the Upper Egyptian Deserts.* Edinburgh and London.

Weill, R. 1904. *Recueil des Inscriptions Égyptiennes du Sinai.* Paris.

Weinstein, J. 1973. *Foundation Deposits in Ancient Egypt.* Ann Arbor.

Weiss, L. 2009. Personal religious practice: House altars at Deir el-Medina. *JEA* 95: 193–208.

Wendrich, W. 2010a. Egyptian archaeology: From text to context. In: W. Wendrich (ed.) *Egyptian Archaeology.* Wiley-Blackwell. 1–14.

Wendrich, W. 2010b. Epilogue: Eternal Egypt deconstructed. In: W. Wendrich (ed.) *Egyptian Archaeology.* Wiley-Blackwell. 274–278.

Wendorf, F. 1977. Late Pleistocene and recent climatic changes in the Eastern Sahara. *The Goegraphical Journal* 143.2: 211–234.

Wendorf, F. Schild, A. & Associates. 2001. *The Archaeology of Nabta Playa*. New York: Kluwer Academic/Plenum.

Wendorf, F. Schild, A. and Zedeno, N. 1996. A late Neolithic megalithic complex in the eastern Sahara. A preliminary report. In: Krzyzaniak, L. (ed.) *Interregional Contacts in the Later Prehistory of North Eastern Africa.* Poznan: Poznan Archaeological Museum. 125–132.

Wheatley, D. 1995. Cumulative viewshed analysis: A GIS-based method for investigating intervisibility and its archaeological application. In: Lock, G. and Stančič, Z. (eds.) *Archaeology and Geographical Information Systems.* London: Taylor and Francis. 171–186.

Wheatley, D. 1996. The use of GIS to understand regional variation in earlier Neolithic Wessex. In: H. D. G. Maschner (ed.) *New Methods, Old Problems – Geographical Information Systems in Modern Archaeological Research.* Illinois: Southern Illinois University at Carbondale, occasional paper 23. 75–103.

Wheatley, D. and Gillings, M. 2000. Vision, Perception and GIS: developing enriched approaches to the study of archaeological visibility. In. Lock, G. (ed.) *Beyond the Map* Amsterdam. 1–27.
Wheatley, D. and Gillings, M. 2002. *Spatial Technology and Archaeology. The Archaeological Applications of GIS.* London and New York: Taylor and Francis.

Wilkinson, R. H. 1994. *Symbol and Magic in Egyptian Art.* London: Thames and Hudson.

Wilkinson, R. H. 2000. *The Complete Temples of Ancient Egypt.* London: Thames and Hudson.

Williams, B. 2006. The cave shrine and the gebel. In: E. Czerny, I. Hein, H. Hunger, D. Melman, and A. Schawb (eds.) *Timelines: Studies in Honour of Manfred Bietak III.* Orientalia Lovaniensia Analecta 149. Leuven: Peeters. 149–158.

Wimmer, S. 1990. Egyptian temples in Canaan and Sinai. In: Israelit-Groll, S. (ed.) *Studies in Egyptology presented to Miriam Lichtheim 2*, Jerusalem: Magnes Press, Hebrew University. 1065–1106.

Winlock, H. 1936. *Ed Dakhleh Oasis: Journal of a Camel Trip Made in 1908.* New York.

Witcher, R. 1999. GIS and landscapes of perception. In: M. Gillings, D. Mattingly and van Dalen, J. (eds.) *The Archaeology of Mediterranean Landscapes. Vol. 3: Geographical Information Systems and Landscape Archaeology.* Oxford: Oxbow Books. 13–22.

Woodman, P. E. 2000. Beyond significant patterning, towards past intentions: The location of Orcadian chambered tombs. In: Buck, C. Cummings, V. Henley, C. Mills, S. and Trick, S. (eds.) *Proceedings of the UK Chapter of Computer Applications and Quantitative Methods in Archaeology 1999.* BAR International Series 844. Oxford: Archaeopress. 91–105.

Wylie, A.1992a. The interplay of evidential constraints and political interests: Recent archaeological research on gender. *AA* 57: 15–35.

Wylie, A. 1992b. On ‘Heavily decomposing red herrings’: Scientific method in archaeology and the ladening of evidence with theory. In: L. Embree. (ed.). *Metaarchaeology.* Dordrecht: Kluwer.

Wylie, A. 2000. Questions of evidence, legitimacy and the (dis)union of science. *AA* 65: 227–238.

Yang, X. and Hodder, T. 2000. Visual and statistical comparisons of surface modelling techniques for point-based environmental data. *CGIS* 27: 165–175.

Yakam-Simen, F. Nezry, E. and Ewing, J. 1999. A legendary lost city found in the Honduran Tropical Forest using ERS-2 and JERS-1 SAR imagery. *Proceedings of the IGARSS 1999 Geoscience and Remote Sensing Symposium* 5: 2578-2580.

Yugsi, F. Eisenbeiss, H. Remondino, R. and Winkler, W. 2006. Multi-temporal monitoring of landslides in archaeological mountainous environments using optical imagery. The case of El-Tambo, Ecuador. In: S. Campana and M. Forte, (eds.) *From Space to Place: 2nd International Conference on Remote Sensing in Archaeology.* BAR International Series 1568. Oxford: Archaeopress. 173–178.

Yuqing, W. Kelong, T. Xiaohu, Z. Dewen, S. Qingbo, D. and Xinlong, N. 2004. Discussion about the function of remotely sensed images in archaeology. In: C. Wang. (ed.) *International Conference on Remote Sensing Archaeology.* Beijing: Chinese Centre for Remote Sensing Archaeology.

Zakrzewski, S. R. 2003. Variation in Egyptian stature and body proportion. *American Journal of Physical Anthropology* 121: 219–229.

Zhang, H. Bevan, A. and Guo, D. 2013. The Neolithic Ceremonial Complex at Niuheliang and Wider Hongshan Landscapes in Northeastern China. *Journal of World Prehistory* 26: 1–24.

Zibelius-Chen, K. 1986. Tempelgründung. In: W. Helck and E. Otto. (eds.) *LÄ VI.* Wiesbaden: Otto Harrassowitz. 385–386.

Zweifel, L. Böni, Th. and Rühli, F. J. 2009. Evidence-based palaeopathology: Meta-analysis of PubMed-listed scientific studies on ancient Egyptian mummies. *Journal of Comparative Human Biology* 60: 405–427.